Research Paper

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What near-term climate impacts should worry us most?

Supporting the most exposed and vulnerable societies to reduce regional and global climate risks

Daniel Quiggin, Ruth Townend and Tim G. Benton

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Contents

Summary

— This research paper draws on the findings of a structured, multi-round expert elicitation exercise, involving 200 climate scientists and specialists in other relevant disciplines, to assess which near-term climate hazards and impacts should most concern decision-makers in the coming decade.

Findings and conclusions

— Between now and 2030, climate hazards will have increasingly significant, disruptive impacts.

— The 10 direct hazard-impact pathways of greatest near-term concern all relate to Africa or Asia.

— Many socio-economic vulnerabilities to climate hazards have been identified in these regions. If left unaddressed, such vulnerabilities have the potential to initiate complex chains of impacts that are likely to have a destabilizing effect on national and international security in the near term.

— Decisive action is urgently needed to address socio-economic vulnerabilities to climate hazards in these regions. Such action can help prevent devastating local and regional impacts, and forestall cascading and compounding global climate impacts within the next decade.

— The near-term impacts of greatest concern are:

  — Cascading impacts on food security, migration and global supply chains, originating in the most vulnerable countries and affecting regional country groups and the wider global community.

  — Food security impacts in South and Southeast Asia, and Australasia.

  — Global food security impacts arising from multiple climate hazards, including extreme heat, drought, storm damage, flooding and multiple breadbasket failure.

  — Migration and displacement impacts in East Africa, South, Southeast and East Asia, the Caribbean and Central America.

  — Cyclones and typhoons in Southeast and South Asia causing significant infrastructure loss and damage, with global cascading impacts on international supply chains.

- Drought and crop failure driving displacement and migration of people from East Africa and the Sahel into Southern Europe.
- Drought directly creating conditions for conflict in Africa, with particular vulnerability in East Africa.
- Changing rainfall patterns and drought impacting livelihoods and income in Africa.

Recommendations

- Adaptation measures are urgently needed. In the near term, global adaptation efforts must focus on addressing socio-economic vulnerabilities in the most threatened regions. Already, 33 concrete food security measures have been identified by 21 African countries. These provide a starting point for action.
- Urgent adaptation action in vulnerable countries and regions should be financed and supported by richer countries. Such action is in the interests of all nations, to prevent cascading food insecurity, migration and conflict across the world. That 'no one is safe until everyone is safe', repeated so often during the COVID-19 pandemic, is just as critical in relation to climate hazards.
- Adaptation measures should, at a minimum, not increase the risk of conflict, and should where possible enhance peacebuilding, given that many socio-economic vulnerabilities are interlinked with domestic and regional tensions. Efforts to combine adaptation and peacebuilding require improved governance, security and economic growth, and – crucially – the buy-in of affected communities.
- A comprehensive and up-to-date climate risk register is needed, incorporating near-term climate impacts (including cascading impacts), socio-economic vulnerabilities and associated adaptations. This should complement the outputs of climate impact models to enable more targeted action from the private sector and governments. Many experts recommend that a UN body such as the Security Council should hold this risk register.
- Mitigation of climate change is fundamental. In the absence of more ambitious NDCs and sector initiatives leading to drastic emissions reductions in the very near term, by 2030 the world may well be locked into impacts so severe they go beyond the limits of what nations can adapt to.
- Repeating this exercise, with modifications and improvements, would be valuable while more comprehensive systems for tracking emerging and near-term climate risks are established.

01 Introduction

As the impacts from climate change become more apparent, near-term climate impacts remain stubbornly difficult to predict within existing models. The expert elicitation exercise described in this research paper explores this gap and its implications for policymakers.

The impacts of climate change have often been framed as a distant and uncertain threat. However, with global warming now standing at nearly 1.3°C above pre-industrial levels,[1,2] climate change is evidently already happening. Its impacts are increasing in frequency, severity and tangibility every year.

To give examples from just the first nine months of 2021, hundreds were killed and thousands of homes destroyed in Germany, Belgium and the Netherlands due to flash flooding; and in New York City and the northeast US, a flash flood of a severity expected only one in every 500 years killed over 50 people. At least half a million children are expected to be acutely malnourished as Madagascar continues to suffer its worst drought in four decades. In India, Maharashtra state experienced its heaviest rainfall in 40 years, causing flooding and landslides in which at least 125 people died. Exceptionally high temperatures across northern parts of the US and Canada led to around 500 deaths in British Columbia alone. Wildfires blazed across Russia, Italy, Greece, the US and Canada. Freezing temperatures in Texas led to power blackouts, lack of safe drinking water, and a shutdown of factories that contributed to a global shortage of silicon chips for computers and cars. All these events were made more likely by climate change; and the northern hemisphere impacts are likely to be related to changes in the jet stream, causing hot- or cold-air incursions to form and linger.[3]

1 Met Office (2021), '2020 ends earth's warmest 10 years on record', 14 January 2021, https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2021/2020-ends-earths-warmest-10-years-on-record.
2 IPCC: Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M. I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J. B. R., Maycock, T. K., Waterfield, T., Yelekçi, O., Yu, R. and Zhou, B. (eds.) (2021, in press), *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press.
3 Kornhuber, K. et al. (2020), 'Amplified Rossby waves enhance risk of concurrent heatwaves in major breadbasket regions', *Nature Climate Change*, 10(1): pp. 48–53, https://theconversation.com/the-north-american-heatwave-shows-we-need-to-know-how-climate-change-will-change-our-weather-163802.

Improvements in climate models and climate impact models have increased understanding of the climate hazards and impacts we all face. For instance, current modelling indicates that the global population and land area exposed to six categories of extreme events have already more than doubled, and are projected to increased fivefold with 2°C of warming relative to pre-industrial levels.[4] However, the severity and frequency of climate impacts remains stubbornly difficult to predict, both in the near term, to 2030, and beyond. Several factors contribute to this:

- First, while climate models robustly predict changes in the climate (e.g. mean temperature), predicting variability in highly localized weather patterns remains difficult, especially as regards extremes.
- Second, thresholds of impact vary from place to place, and this variation is not well tracked or quantified,[5] meaning climate impact models struggle to accurately quantify climate impacts. For instance, a 35°C heatwave may be experienced very differently in different regions of the world. Where the economy is predominantly agricultural, and where workers are unable to escape the heat, it may be devastating. In another region with a predominantly service economy, workers in air-conditioned offices will suffer very little personal impact. Thus, translating climate hazards through populations' exposures and vulnerabilities is very complex, and is often downplayed in risk management.[6]
- Third, and perhaps most importantly, systemic climate risks and impacts can cascade and amplify across nations and borders, having an impact far from the original climate hazard.[7] For example, the global food crisis of 2007–08 was sparked by Australian drought and regional crop failures, but led to a doubling of global food commodity prices, insecurity for countries reliant on food imports, and social unrest and mass protests in at least 13 countries.[8,9] Such cascading impacts are nearly impossible to predict within climate impact models, or sometimes even to imagine.
- Finally, as the time horizon we are concerned about with regard to climate impacts extends, robust characterization of earth system 'tipping points'[10] within climate models becomes a compounding issue for accurately predicting

4 Lange, S. et al. (2020), 'Projecting Exposure to Extreme Climate Impact Events Across Six Event Categories and Three Spatial Scales', *Earth's Future*, 8(12), doi:10.1029/2020EF001616.
5 Arnell, N. W., Lowe, J. A., Bernie, D., Nicholls, R. J., Brown, S., Challinor, A. J. and Osborn, T. J. (2019), 'The global and regional impacts of climate change under representative concentration pathway forcings and shared socioeconomic pathway socioeconomic scenarios', *Environmental Research Letters*, 14(8), 084046, doi:10.1088/1748-9326/ab35a6.
6 Challinor, A. and Benton, T. G. (2021), *UK Climate Risk Independent Assessment (CRRA3), Chapter 7: International Dimensions*, https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Chapter-7-FINAL.pdf.
7 Carter, T. R. et al. (2021), 'A conceptual framework for cross-border impacts of climate change', *Global Environmental Change*, 69, 102307, doi:10.1016/j.gloenvcha.2021.10.
8 Wright, B. D. (2011), 'The economics of grain price volatility', *Applied Economic Perspectives and Policy*, 33(1): pp. 32–58, doi:10.1093/aepp/ppq033.
9 Spiegel International (2008), 'Global Food Crisis: The Fury of the Poor', 14 April 2008, https://www.spiegel.de/international/world/global-food-crisis-the-fury-of-the-poor-a-547198.html.
10 Earth system tipping points are thresholds at which a small change could push earth systems into a new state, and which may create sudden or unpredictable changes. Climate scientists are concerned about numerous earth system tipping points that are likely to be both triggered by, and accelerate, climate change.

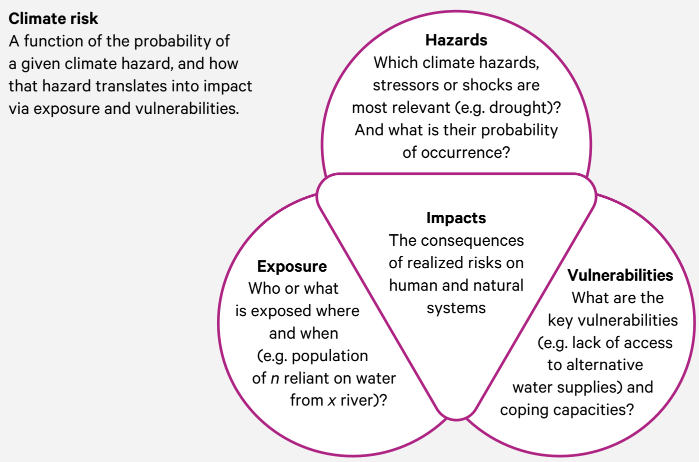
climate impacts. Evidence is mounting that these tipping points are swiftly being reached,[11] yet many climate models fall short of incorporating their dynamics fully.[12]

Given swiftly increasing climate hazards, combined with difficulties in determining what impacts might occur, and how these might play out, work is urgently needed to quantify the most concerning near-term climate hazards and impacts. This research paper sets out the findings of an expert elicitation process, conducted by analysts at Chatham House, to assess which climate hazards and impacts decision-makers should be most concerned about – and prepared for – over the next decade. The paper also explores where greater monitoring of climate risks is needed to avoid or minimize the most severe climate impacts.

Box 1. Climate risks: from hazards to impacts

Risk analysis considers the probability of a given severity of impact. In quantifying climate risk, risk is a function of the probability of a given climate hazard, and how that hazard translates into impact via societies' exposure and vulnerabilities to the hazard. Impacts are the consequences of realized risks on human and natural systems.[13]

Figure 1. Defining climate risk



Source: Adapted from UN Climate Security Mechanism's conceptual approach.[14]

Examples of climate hazards include hydrological droughts, heatwaves and changes in rainfall patterns. Corresponding examples of impacts include increased water scarcity and resulting mortality, people's inability to work outside due to extreme heat, and river flooding displacing people. The severity of each of these impacts is contingent on the exposure (e.g. the number of people affected, or a country's degree

11 Ripple, W. J. et al. (2021), 'World Scientists' Warning of a Climate Emergency 2021', *BioScience*, 71(9), doi:10.1093/BIOSCI/BIAB079.
12 Lenton, T. M. et al. (2019), 'Climate tipping points — too risky to bet against', *Nature*, 575(7784), doi:10.1038/d41586-019-03595-0.
13 IPCC: Masson-Delmotte et al. (2021, in press), *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis.*
14 UN (2020), 'Climate Security Mechanism: Toolbox: Conceptual Approach', https://dppa.un.org/sites/default/files/csm_toolbox-2-conceptual_approach.pdf.

of reliance on an impacted supply chain) and vulnerability to the corresponding hazard (e.g. access to infrastructure able to supplement water supply, or whether shortage of goods can be compensated from alternative sources) (Figure 1).

Risks can also arise from human responses to climate change that may increase exposure or vulnerability.[15] Social inequality is meanwhile also rising globally,[16] and this may increase vulnerability to risks. Understanding these dynamics is important as countries are ever more integrated in globalized systems, which may increase exposure to 'cascading' climate risks.[17]

Exposure refers to the 'inventory' of human and natural resources, ecosystems, economic elements and infrastructure, all existing in a given area, that may be impacted by climate hazards. Exposure could be to direct impacts, such as when extreme weather directly impacts local agricultural populations and produce; or indirect, such as when climate change hazard impacts are transmitted from overseas through changes in the movement of goods, finance or people. If people and economic resources are not 'exposed' by existing in these potentially dangerous settings, there is no risk from the hazard in question.

Vulnerability defines the propensity of exposed 'elements' such as people, their livelihoods and their assets to suffer adverse effects when impacted by hazard events. It is the degree to which natural, human and economic elements may be susceptible to, and unable to cope with, adverse effects of a given climate change hazard when such effects materialize. Again, these vulnerabilities may be to local hazards or to impacts transmitted through the flow of goods, people or finance to a community, affecting the price and availability of goods. Typically, the poorest people in any society are most vulnerable as they have the fewest resources to mitigate the impacts facing them.[18]

Exposures and vulnerabilities to different hazards are inherently related to the socio-economic, political, geographic and environmental contexts in which the elements are situated. In theory, even though climate hazards are increasing, climate risks could simultaneously be decreasing, through effective adaptation measures that reduce exposure, vulnerability and impact. Coping or adaptive capacity is therefore critically important within this context. For instance, Bangladesh and the Netherlands both face sea level rise, but the adaptive capacity in the Netherlands may enable more effective and faster adaptation, and hence decrease the risk to the country. However, the radical uncertainty of the socio-economic and political contexts (as well as the increasing uncertainty of extreme weather due to changing climate) means the overall risk from indirect as well as direct impacts is very difficult to quantify,[19] and therefore has often been downplayed from a risk management perspective.

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15 Ibid.
16 Court, C. D. et al. (2021), 'Accounting for global value chains: rising global inequality in the wake of COVID-19?', *International Review of Applied Economics*, doi: 10.1080/02692171.2021.1912716.
17 Puma, M. J. et al. (2015), 'Assessing the evolving fragility of the global food system', *Environmental Research Letters*, 10(2), doi:10.1088/1748-9326/10/2/024007.
18 Otto, I. M. et al. (2017), 'Social vulnerability to climate change: a review of concepts and evidence', *Regional Environmental Change*, 17(6), doi:10.1007/S10113-017-1105-9.
19 Mizen, P. (2021), 'John Kay and Mervyn King: Radical uncertainty: decision-making beyond the numbers', *Business Economics 2021,* 56(2), doi:10.1057/S11369-020-00204-1.

A systemic, or cascading, climate risk is the probability of a sequence of cascading impacts initially triggered by a climate hazard: from direct impact, to first-order indirect impact, to second-order indirect impact, and so on. Along this chain, or cascade, of impacts, a sequence of vulnerabilities and exposures exist that mediate or expedite the progression of the cascade of impacts. It should be noted that the cascade of impacts can progress in a non-linear manner, as they interact with complex systems, such as regional economies or geopolitical dynamics between countries.[20] Further, as individuals, societies and governments begin adapting, their adaptive measures may themselves in turn become a source of risk.[21]

20 UN (2020), 'Climate Security Mechanism: Toolbox: Conceptual Approach'.
21 Ibid.

02 Approach and methodology

2.1 A modified Delphi method

As part of the research that has informed this paper, a modified, online, Delphi method[22] was used to collectively reach consensus on the most concerning near-term (i.e. a time horizon up to 2030) pathways of climate impact. These were defined as the climate hazards that are likely to lead to impacts of significance to people or societies, either directly or through risks propagating across borders (such as through displacement of people, or via disrupted supply chains).

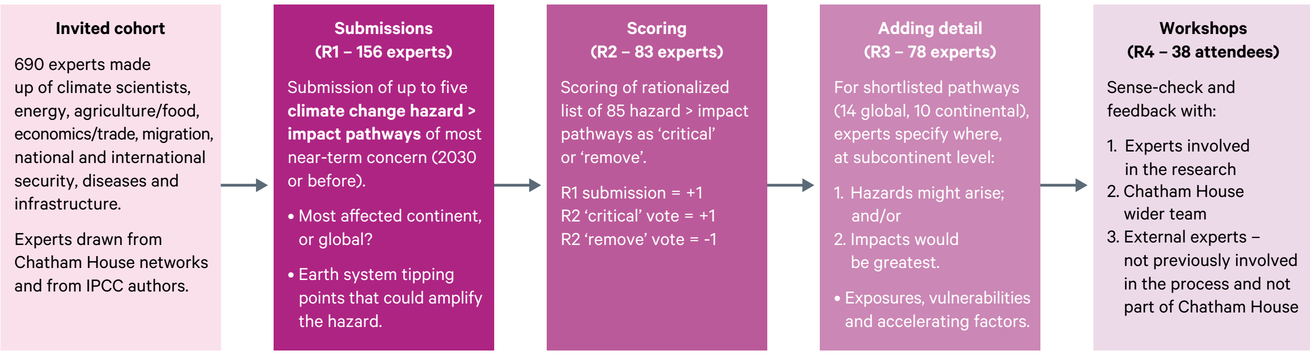
The Delphi method works on the basis that opinions from experts engaged in a structured process are more accurate than unstructured expert opinions.[23] Experts respond to questions set by the research team, through two or more survey rounds. After each round, the facilitator provides an anonymized summary of the previous round's information, and experts may revise their opinions/rankings based on the views of other (anonymized) experts. The aim is that, through the process, the expert group converges towards a reliable and robust consensus – in this case to identify hazard-impact pathways that are of most concern.

A three-round modified Delphi method expert elicitation exercise (summarized in Figure 2) was conducted, with two final feedback workshop sessions constituting a fourth 'round' or sense-check. Due to COVID-19 restrictions, the research was conducted entirely online. A total of 690 experts, drawn from Chatham House's networks and supplemented with published IPCC authors, were invited to participate at each round. Some experts took part in all rounds, while others joined only one or two of the rounds. In all, 200 experts participated in one or more rounds. Experts were not required to have taken part in the first round

22 Linstone, H. A. et al. (2002), *The Delphi Method: Techniques and Applications*, https://web.njit.edu/~turoff/pubs/delphibook/delphibook.pdf; Sackman, H. (1974), *Delphi Assessment: Expert Opinion, Forecasting and Group Process*, https://www.rand.org/content/dam/rand/pubs/reports/2006/R1283.pdf; Brown, B. B. (1968), *Delphi Process: A Methodology Used for the Elicitation of Opinions of Experts*, RAND Corporation; Dalkey, N. and Helmer, O. (1963), *An Experimental Application of the DELPHI Method to the Use of Experts*, http://dx.doi.org/10.1287/mnsc.9.3.458.
23 Rowe, G. and Wright, G. (2001), 'Expert Opinions in Forecasting: The Role of the Delphi Technique', *Principles of Forecasting*, pp. 125–144, doi:10.1007/978-0-306-47630-3_7.

to join in the second or third, so some experts came fresh to the research at each round. At Round 1, participating experts were asked to categorize their expertise by subject area and by geographic reach (Figure 3).[24]

Figure 2. Summary of the modified Delphi method expert engagement process, conducted over four rounds, 1 March to 9 June 2021



Note: In all, 200 experts participated in one or more rounds of the exercise, from an invited cohort of 690.

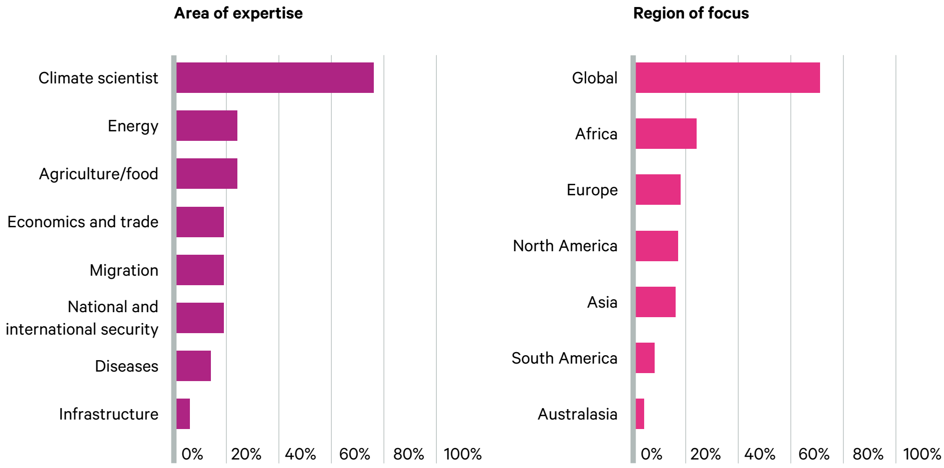
Based on the demographics of the experts involved in the modified Delphi process (Figure 3), there was sufficient geographic and domain expertise for the group to collectively highlight, prioritize and assess the potential impacts of greatest significance. Participating experts came from a broad range of disciplines; and, in common with many applications of the Delphi method,[25] the research team chose not to 'rate' experts or ask them to rate themselves. Similarly, experts' rankings and votes were not weighted; instead, all expert votes were given equal weight, and the consensus of the group was used to quantify the relative importance of hazard-impact pathways.

At Round 1, the majority of the 156 participating experts (76 per cent) described themselves as climate scientists, and this was often in combination with other expertise. Around a quarter had expertise in energy, and a similar number had expertise in agriculture/food. One in five had expertise in each of economics and trade, migration, or national and international security. Smaller numbers were experts in diseases (14 per cent) or infrastructure (6 per cent).

It should be noted that all quotes from experts used in this report are anonymized.

24 Note that at Rounds 2 and 3 experts were not asked for this information. This was to avoid the research being unduly burdensome for those who had already participated. In all, 95 per cent of Round 1 participants also participated in Round 2. At Round 3, 50 per cent of participants had also participated in Round 1. The authors believe this was due to IPCC deadlines coinciding with the research period, which meant many Round 1 participants were not available to participate in the research at that time.
25 Gordon, T. J. (2016), 'The Delphi Method – The Red Team Analysis Society', https://www.redanalysis.org/wp-content/uploads/2016/06/04-Delphi.doc.

Figure 3. Expertise and region of focus of the experts participating in Round 1 of the Delphi process (156 participants)



Note: Percentages add up to more than 100 because some experts classed themselves under multiple categories.

2.2 Strengths and uniqueness of approach

There is significant discussion within the climate community about the extent to which climate models and climate impact models are fit for purpose for predicting the incidence and severity of climate hazards and impacts.[26] Furthermore, detailed assessments in the published literature – such as IPCC reports and the UK's Climate Change Risk Assessment – may be highly conservative in their assessments of risks if the models themselves under-represent the hazards.[27] Such assessments may not, therefore, be the best source for qualitatively understanding the way discrete hazards and their impacts will evolve in future. An expert elicitation process, as used to inform this paper, enables domain experts to unpack how they assess risks in their areas of expertise, and to bring in the range of evidence that they have access to. The Delphi method, while qualitative, balances individual subjectivity by building a degree of consensus across experts. This approach therefore complements formal quantitative assessment studies.

For this exercise, the Delphi method's strength is that it allows a space for climate scientists and sector risk experts to express concerns with respect to hazard-impact pathways that are currently difficult to forecast with confidence, but whose societal impacts are likely to be significant. Furthermore, while formal climate risks assessments tend to focus on medium to longer time periods, this study focuses on hazard-impact pathways that experts identify as being of concern in the near term, to 2030.

26 Schewe, J. et al. (2019), 'State-of-the-art global models underestimate impacts from climate extremes', *Nature Communications*, 10(1), doi:10.1038/s41467-019-08745-6; Harrabin, R. (2021), 'Climate change: Science failed to predict flood and heat intensity', BBC News, 16 July 2021, https://www.bbc.co.uk/news/science-environment-57863205; Bartell, P. (2021), 'Extreme weather takes climate change models 'off the scale'', *Financial Times*, 24 July 2021, https://www.ft.com/content/9a647a51-ede8-480e-ba78-cbf14ad878b7.
27 Schewe et al. (2019), 'State-of-the-art global models underestimate impacts from climate extremes'.

03 Results and discussion

The severity of climate impacts will be amplified by existing and future socio-economic vulnerabilities in key regions. If ignored, these critical vulnerabilities will catalyse cascading impacts, creating instability across regions and globally.

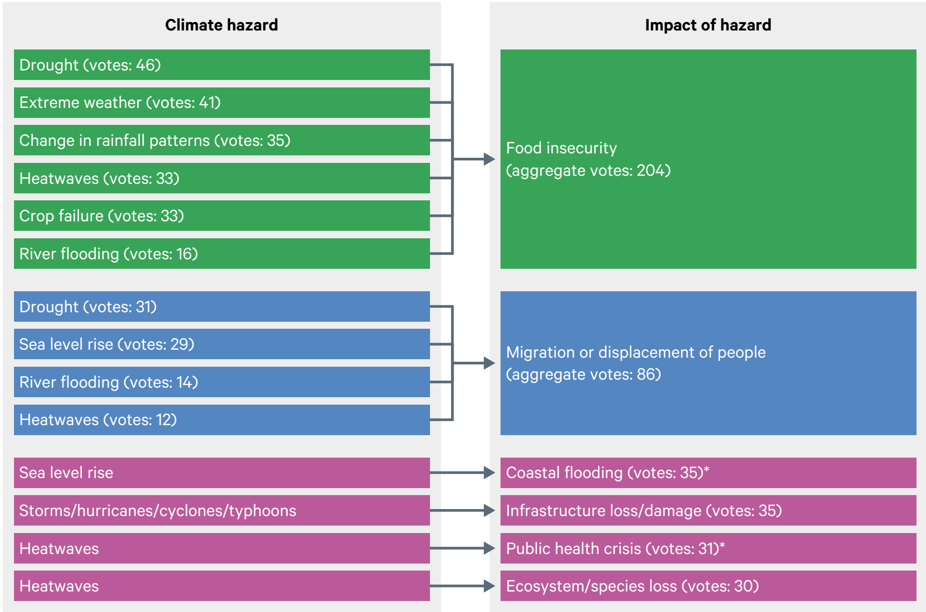
3.1 Climate hazard-impact pathways

Two 'shortlists' of near-term climate hazard-impact pathways, one global, one continental, were drawn together through the first two rounds of the Delphi method expert engagement.

3.1.1 Global hazard-impact pathway shortlist

The global hazard-impacts pathways of greatest concern to the participants are detailed in Figures 4 and 5. The 21 individual pathways submitted at Round 1 were grouped by theme, according to the 'impact' element of the hazard-impact pathway. Three themes emerged: food insecurity; migration or displacement of people; and 'other' pathways, such as impacts on public health and damage to infrastructure that may have significant socio-economic impacts.

Figure 4. Global hazard-impact pathways shortlist, showing climate hazards and their impacts



* Hazard-impact pathways can involve many steps, and climate hazards and impacts often overlapped in expert submissions. For example, drought can lead to food insecurity which may contribute to human displacement. Coastal flooding could lead to inundation of communities, infrastructure loss and loss of livelihoods. A public health crisis could result directly from extreme heat, or from damage to crops because of extreme heat, or could exacerbate other climate hazards and impacts such as wildfires or even pandemics.
Source: Chatham House expert elicitation exercise.

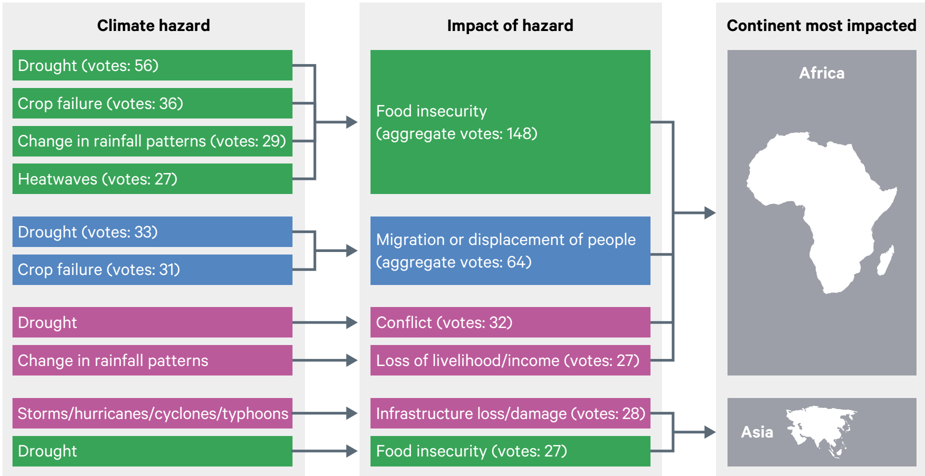
Figure 5. Near-term climate hazard-impact pathways of most concern to experts engaged at Rounds 1 and 2

Note: The highlighted pathways were put forward for further expert engagement in Round 3.
Source: Chatham House expert elicitation exercise.

3.1.2 Continental hazard-impact pathway shortlist

The continental hazard-impact pathways of greatest concern are shown in Figure 6. The top 10 hazard-impact pathways identified all related to Africa (eight pathways) or Asia (two pathways). Food insecurity and migration and displacement of people were ranked highly among the continental hazard-impact pathways, as they were among the global hazard-impact pathways.

Figure 6. Continental hazard-impact pathways shortlist, showing climate hazards and their impacts, alongside the continent where impacts from the hazard are likely to be greatest



Source: Chatham House expert elicitation exercise.

3.2 Risk amplifiers

Two categories of risk amplifiers were discussed in detail throughout the research process: earth system tipping points; and socio-economic vulnerabilities. Both have the potential to amplify risk, either by exacerbating the climate hazards, or by exacerbating the impacts from these hazards.

3.2.1 Earth system tipping points

Earth system tipping points are thresholds at which an incremental change – perhaps of a driving variable that has changed incrementally for decades with little impact – reaches a point where it pushes the earth system (or major subsystems) into a new state.[28] Such tipping points can be thought of as critical thresholds that, if crossed, initiate non-linear and potentially irreversible changes (Figure 7). These changes may be sudden, but are likely to play our over long periods of time.[29]

Experts' concerns about the initiation of earth system tipping points in the near term reflects growing awareness that some of these thresholds may be reached at lower temperatures than previously thought.

One of the objectives of the research that has informed this paper was to establish whether experts believe that passing critical thresholds might increase the probability or severity of specific hazard-impact pathways occurring by 2030. While there were many suggestions of tipping points that could be passed in the near-term time horizon (Figure 7), the consensus from the experts was strong around two points. The first was that whereas some tipping points may be close, or even have already been passed (such as melting of some ice sheets), **it is unlikely their impacts will amplify risks** appreciably before 2030.[30] Second, **socio-economic vulnerabilities to specific climate hazards are more likely to amplify the impacts of climate hazards within the specified timeframe (to 2030)** than are earth system tipping points.

> I would rather suggest to think about combined social-ecological tipping points or social tipping points within the context of climate change impacts.
> **Anonymized expert, Round 1**

Experts' concerns about the initiation of earth system tipping points in the near term reflects growing awareness that some of these thresholds may be reached at lower temperatures than previously thought. IPCC climate models indicate a cluster of tipping points may be initiated between 1.5°C and 2°C.[31,32] Temperature increases are already nearly 1.3°C above pre-industrial levels.[33]

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28 Lenton et al. (2019), 'Climate tipping points — too risky to bet against'.
29 For example, absorption of increasing atmospheric CO_2 into the marine environment leads to the gradual acidification of the seas, which at a given critical threshold, determined by the physiology of the coral, causes the dieback of coral and the collapse of reef-dependent fisheries.
30 While the tipping points may each be a threshold, the consequences for the system's dynamics may play out over long time periods (for example, sufficiently warmed oceans will preclude any sea ice, but it may take hundreds of years for the current ice to melt and the sea level to equilibrate to new levels.
31 Drijfhout, S. et al. (2015), 'Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models', *Proceedings of the National Academy of Sciences of the United States of America*, 112(43), doi:10.1073/pnas.1511451112.
32 Ripple, W. J. et al. (2021), 'World Scientists' Warning of a Climate Emergency 2021', *BioScience*, 71(9), doi:10.1093/BIOSCI/BIAB079.
33 Met Office (2021), '2020 ends earth's warmest 10 years on record'.

Figure 7. Map of earth system tipping points of concern (boxed text summarizes experts' responses)

Tipping points of concern, identified by participating experts

Circulation change

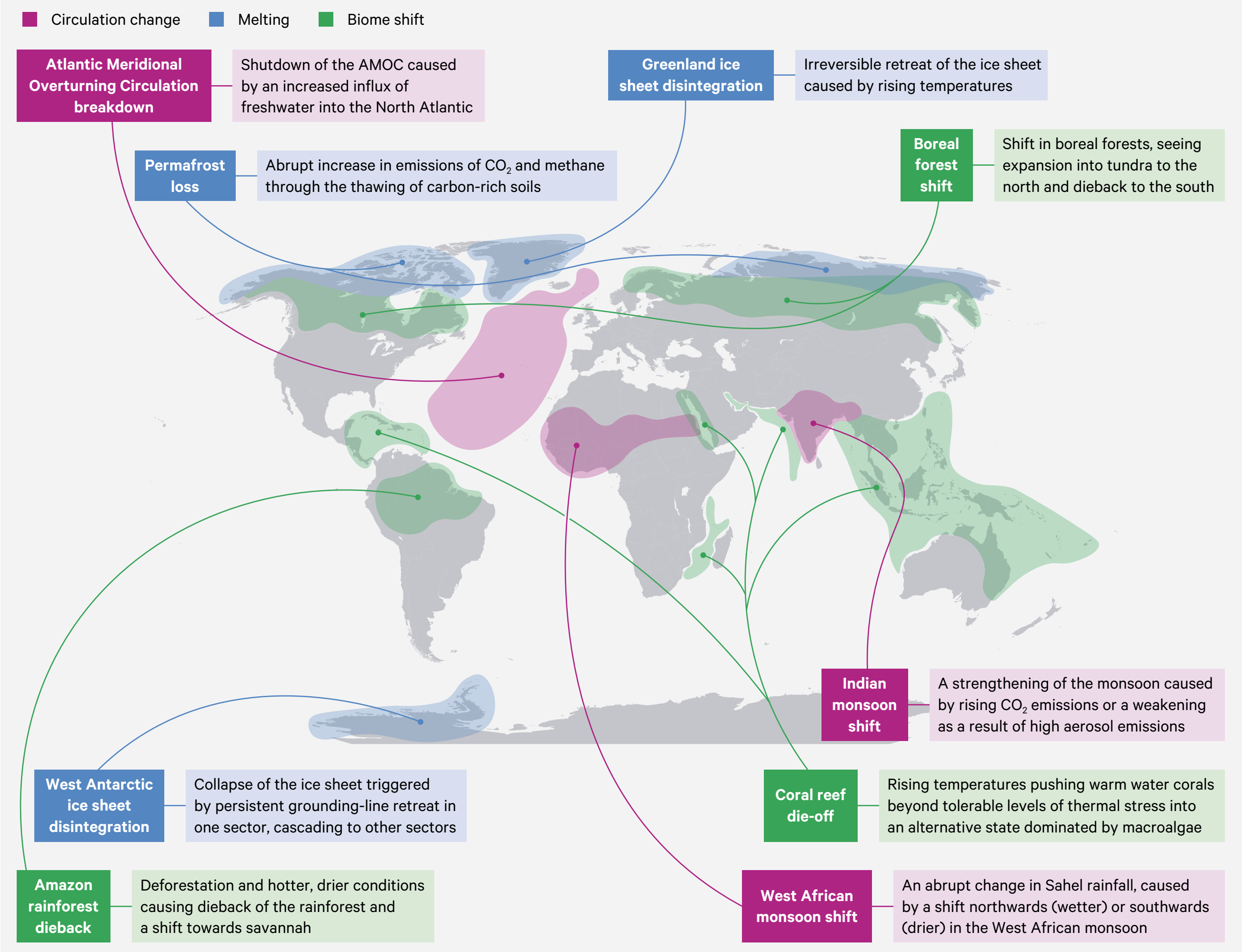
- *Changes to ocean circulation, leading to regional spike in temperatures*
- *Shifts in AMOC*
- *Jet stream shifts*
- *A multi-year variability mode (ENSO, NAO, monsoon)*
- *Changes in SST and atmospheric circulation patterns*
- *New peak of the Pacific decadal oscillation*
- *Increased occurrence and/or magnitude of El Niño/La Niña events and shifts in monsoon patterns*
- *Slowdown of AMOC amplifies sea level rise*
- *Thermobaline circulation slow down (2030) or collapse (later). Slows down the northward surface heat transfer to Atlantic SST, more energy for intense and frequent storms*
- *Co-occurrence of increased short-term climate variability (e.g. ENSO-La Niña Phase 1 Pacific decadal oscillation)*
- *Southerly shift in Hadley cell*
- *Indian monsoon instability and relative monsoon failure*

Melting

- *Methane emissions from permafrost, tundra melt and sub-soil fires*
- *Loss of mountainous glaciers*
- *Loss of albedo*
- *Accelerated melting of Greenland, Arctic and Western Antarctic ice sheets*
- *Loss of Himalayan meltwater and bursting glacial lakes*

Biome shift

- *Widespread deforestation and/or tree mortality affecting regional climate*
- *Vegetation dieback and desertification in the Sahel*
- *Biodiversity loss and ecosystem disruption*



Source: Adapted from Carbon Brief (2020).[34]

34 McSweeney, R. (2020), 'Tipping Points Explainer: Nine 'tipping points' that could be triggered by climate change', Carbon Brief, https://www.carbonbrief.org/explainer-nine-tipping-points-that-could-be-triggered-by-climate-change.

3.2.2 Socio-economic vulnerabilities as near-term risk amplifiers

The experts who participated in the Round 4 workshops were nearly unanimous that increasing **socio-economic vulnerabilities to specific climate hazards are more likely to amplify the impacts** of climate hazards within the next decade than passing any critical threshold causing tipping points in the earth system. This assessment applies to impacts on local populations, as well as to cascading systemic risks at local, regional and global scale. As described in Box 1, the magnitude of the risk is crucially dependent on a population's vulnerability, and so the nature and extent of the vulnerability is a factor in determining the magnitude of the risk.

Coastal flooding from storms can be taken as an example of the relative potential for amplifying impacts from socio-economic vulnerabilities to changing climate hazards. Coastal flooding from storms will be exacerbated both by climate change altering the nature of storms, and by the impact of climate change on sea level rise before 2030. In the near term, however, the amplifying impact of these changes will be relatively insignificant when compared to the amplifying impact of socio-economic changes. Exposure and socio-economic vulnerability to coastal flooding is rapidly increasing, due to changing rural-to-urban migration patterns, the growth of coastal cities, poor urban planning and infrastructure, and growing inequality. All of these factors put a greater number of people 'in harm's way' of coastal flooding, and reduce available resources to deal with it, thus increasing vulnerability. These factors are likely to amplify the impacts of coastal flooding in the near term.

As part of the research that has informed this paper, we developed a thematic framework for classifying the key socio-economic vulnerabilities highlighted in relation to the most concerning hazard-impact pathways (Figure 8).

Figure 8. Classification framework for socio-economic vulnerabilities likely to amplify the impacts of climate hazard-impact pathways

Vulnerable conditions

Poor adaptive capacity pre-exists in the local conditions

- Areas that are most susceptible to impacts for example, where a single water source is heavily relied on.
- Farming practices, cropping systems or livestock that are neither resilient nor adaptable to changing conditions.

Lack of resilience or adaptive capacity

Exacerbated locally by the socio-economic-political conditions

- Poverty, which reduces adaptive capacity and opportunity for individuals and societies.
- Weak governance or lack of central structures to coordinate adaptation measures that pre-empt or respond to climate hazards.

Existing fault lines

Such as ethnic tensions, may be worsened by competition for resources

- When climate hazards create primary impacts, secondary impacts or cascades can appear along existing fault lines.
- Climate hazard impacts may also create new fault lines where none previously existed.

External reliance and interdependences

Which may be permanent, or crisis-specific

- May be within countries (e.g. cities reliant on rural farms); between neighbouring countries; or include global markets, international cooperation and governance regimes.
- Dependent parties may have limited agency over those they depend on.

Source: Authors' analysis.

In the next sections, we examine the consensus hazard-impact pathways at global and continental and regional levels in detail (Sections 3.3–3.5), before returning to an analysis of vulnerability (Section 3.6).

3.3 Specific hazard-impact pathways: food insecurity

3.3.1 Impacts on global food insecurity

At global level, climate change-related food insecurity was identified by the participating experts as being the consensus impact of greatest concern (Section 3.1.1). Food insecurity may be caused by multiple climate hazards (from extreme weather in general, or specifically by drought, change in rainfall patterns, heatwaves, flooding, or outbreaks of pests and disease); and increases in global food insecurity can arise from hazards in vulnerable countries, or hazards elsewhere, driving up world food prices, indirectly impacting vulnerable countries by changing local food availability or economic access. The greatest consensus concern over the next decade was for climate hazards arising in East Africa (including concerns about countries in the eastern Sahel and the Horn of Africa), South Asia, West Africa, Southeast Asia and Australasia (Figure 9). These five regions together accounted for 34 per cent of all the experts' votes across hazards connected to food insecurity impacts. Concerning Africa, it was highlighted in discussions many of the votes for East and West Africa concerned the Sahel, which spans both areas.[35]

Greatest concern around continentally initiated climate hazards leading to global food insecurity was focused on drought within East Africa, and flooding in South and Southeast Asia. Cyclones in South and Southeast Asia were also highlighted, in addition to heatwaves, drought, flooding and changing rainfall patterns within the regions illustrated in Figure 9, and widely increased impacts from storm damage.

The potential for **multiple breadbasket failure** was also highlighted by the experts.[36] Such a failure would occur if two or more 'breadbasket' regions that are significant global producers of commodity food crops suffer crop failure at the same time. The top four maize producing countries (the US, China, Brazil and Argentina) account for 87 per cent of the world's maize exports. At present, the probability of a synchronous, greater than 10 per cent crop failure across all four countries is near zero. Under the current global emission trajectory, however, the probability of such a failure rises to around 6.1 per cent each year in the 2040s; and the probability of a synchronous failure during the decade of the 2040s is just less than 50 per cent.[37,38] Significant concern was expressed about the compounding impacts of extreme weather that would likely result in the increased probability of multiple breadbasket failure. Concurrent heatwaves in recent years further illustrate that extreme heat and flooding is increasingly co-prevalent due to planetary wave resonance.[39,40]

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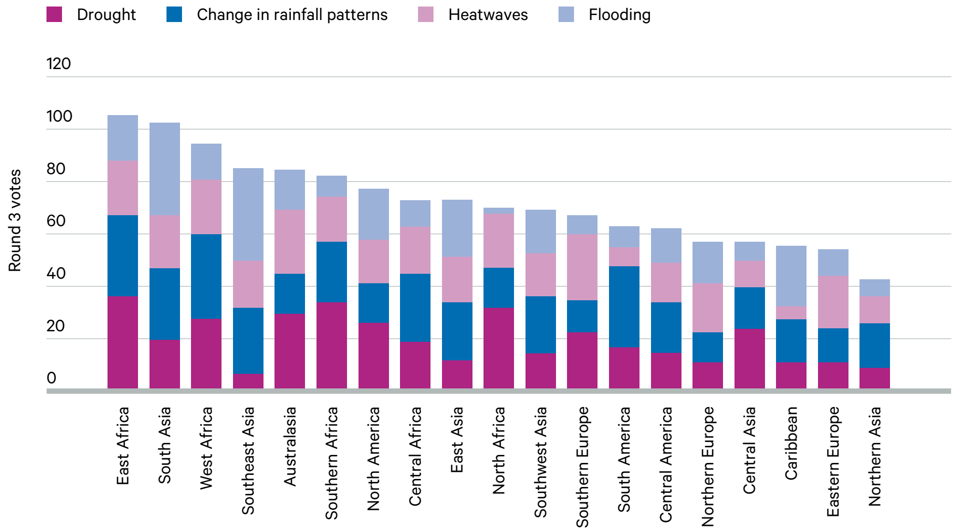
35 It should be noted that the subregional breakdown (Round 3) did not include the Sahel.
36 These concerns were part of the long-form responses given by experts during Rounds 1 and 3, and were also raised during the workshops.
37 Tigchelaar, M. et al. (2018), 'Future warming increases probability of globally synchronized maize production shocks', *Proceedings of the National Academy of Sciences of the United States of America*, 115(26), doi:10.1073/pnas.1718031115.
38 Converted Tigchelaar et al. (2018) temperature thresholds to timeframes, based on RCP4.5 passing relevant temperature thresholds, based on CMIP6 climate models. See https://esd.copernicus.org/articles/12/253/2021/esd-12-253-2021-discussion.html and https://www.carbonbrief.org/analysis-when-might-the-world-exceed-1-5c-and-2c-of-global-warming. Further, converted annual likelihood of 6.1 per cent to probability decadal probability of occurrence.
39 Kornhuber et al. (2020), 'Amplified Rossby waves enhance risk of concurrent heatwaves in major breadbasket regions'.
40 Planetary waves result from the conservation of potential vorticity. They are influenced by the Coriolis force and pressure gradient.

Figure 9. Global food security hazard-impact pathways, illustrating regions where hazards may be initiated and which then go on to cause global impacts (experts' responses)



Source: Chatham House expert elicitation exercise.

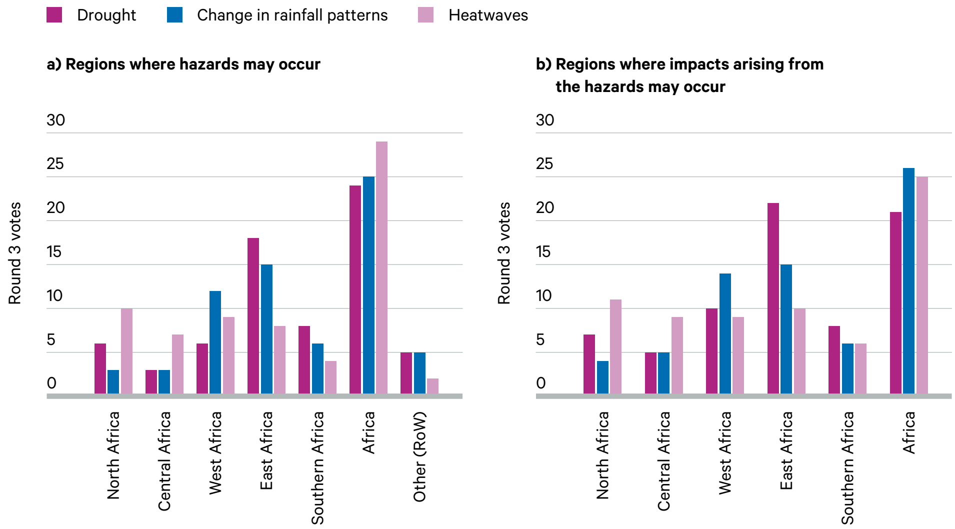
3.3.2 Impacts on food insecurity at continental and regional level

Section 3.3.1 identified, at a global level, where experts thought climate hazards would have the greatest impacts on global food insecurity. A more granular analysis, described in this section, was enabled by asking the participating experts which climate hazards would have the biggest impact on regional food insecurity. In many of the hazard-impact pathways giving rise to food insecurity, Africa and Asia are the primary continents of concern in terms of impacts, as well as the initiating hazards (Figure 10a&b). This indicates dual concerns: that global food insecurity could stem from hazards in these regions impacting more widely through the dynamics of supply and demand (Figure 9); and that the vulnerability of local populations means that these same regions will be most impacted by food insecurity. Again, the Sahel was considered to be of particular concern in the workshops.

The greatest food security concern identified relates to East Africa, due to drought and changing rainfall patterns, coupled with heatwaves within the region, leading to crop failure. However, these climate hazards, crop failure and resulting food insecurity are likely to be felt widely across the African continent because of the fragility of the Sahel (both its socio-economic vulnerability and political instability). Regarding the climate hazards of drought and changing rainfall patterns, 26 per cent and 22 per cent of experts, respectively, identified East Africa of primary concern (Figure 10a); and 17 per cent selected West Africa regarding changing rainfall patterns. Concern regarding heatwaves was evenly spread across African regions. The food insecurity arising from these hazards (Figure 10b) is again likely to be concentrated in East Africa, with 30 per cent of experts selecting this region in relation to drought, and 21 per cent in respect of changing rainfall patterns; and 20 per cent selected West Africa in relation to changing rainfall patterns. As with the distribution of hazards across the regions of Africa, expectations of heatwaves leading to food insecurity were more evenly spread across the African continent, with North Africa being most frequently identified in this respect (16 per cent of participants).

Although not illustrated in Figure 10a&b, drought and changing rainfall patterns were also highlighted as impacting livelihoods and income throughout the African continent.

Figure 10. African regional food security hazard-impact pathways (a) initiated by hazards in various regions; (b) with impacts experienced in various regions (experts' responses)



Source: Chatham House expert elicitation exercise.

Experts also identified continent-specific food security concerns in relation to Asia.[41] When asked to identify the regions of greatest concern for occurrence of hazard-impact pathways to occur, 42 per cent opted for South Asia as the region where drought leading to food insecurity is likely to occur; while 26 per cent identified Asia as a whole as being of concern regarding this pathway. When asked to identify specific regions in which drought-driven impacts of food insecurity in Asia are mostly likely to be felt, 46 selected South Asia, and 14 per cent Central Asia.

The experts' workshop discussion also identified the risks to African and Asian food security arising from hazards elsewhere. As illustrated by the food price spikes in 2007–08 and 2010–11, both triggered by impactful weather (in Australia and Eastern Europe respectively), panic buying on global markets in anticipation of a shortfall in supply, coupled with the imposition of export bans, led to significant spillover effects on markets globally (extending to unaffected grains). This spillover contributed to local price rises, shortages of food aid, significant destabilization of local economies, and mass protests and rioting stemming from food-price inflation (Box 2).

41 These are independent of the global food security impact pathways detailed in Figure 9.

Box 2. Case study: From national food insecurity to regional security concerns, and the role of global markets*

Food security in East Africa and the Sahel is intimately tied to imports from global and regional food markets, and hence global and regional food availability and prices. Table 1 lists the cereals import dependencies of East African and Sahel region countries. Over 50 per cent of cereals consumed in many of these countries are imported. In aggregate, across all the countries listed in Table 1, 23 per cent of their cereals were imported. These import dependencies demonstrate the reliance of these regions on global markets to maintain food security.

Table 1. Cereals import dependencies of East African and Sahel countries (five-year import average, expressed as percentage of 2020/21 food use)

Country	Five-year average imports as % 2020/21 food use
Burkina Faso	16%
Burundi	40%
Cameroon	31%
Chad	8%
Comoros	97%
Djibouti	97%
Ethiopia	8%
Eritrea	74%
Gambia	75%
Guinea	32%
Kenya	46%
Madagascar	21%
Malawi	8%
Mali	10%
Mauritania	76%
Mauritius	177%
Mozambique	39%
Niger	11%
Nigeria	29%
Rwanda	37%
Senegal	55%
Seychelles	107%
Somalia	81%
Tanzania	12%
Uganda	15%
Zambia	3%
Zimbabwe	35%
Average total	**23%**

Source: FAO (2021), Cereal supply and demand balances for sub-Saharan African countries.[42]

42 FAO (2021), *Cereal supply and demand balances for sub-Saharan African countries – Situation as of February 2021*, Rome: Food and Agriculture Organization of the United Nations, doi:10.4060/cb3674en.

Experts expressed concerns about the compounding risks of multiple and synchronous breadbasket failures, as highlighted in Section 3.3.1, and it is clear that this is an increasingly near-term threat.

The global food crisis of 2007–08 led to a doubling of global food prices, food insecurity for importing countries, social unrest, and mass protests in at least 13 countries, including Cameroon, Egypt, Indonesia, Mexico, Morocco, Nepal, Peru, Senegal and Yemen.[43,44] The severe global food price inflation in both 2007–08 and 2010–11 arose in part from climate impacts (Australian drought, and Eastern European crop failures). These impacts interacted with other factors (low food stock transparency, depleted grain stores, and biofuel policy diverting grain to ethanol production), leading to runs on grain markets and to the implementation of export bans by some countries, further amplifying food price increases.

Looking in more detail at the 2010–11 food price spike,[45] the primary trigger was exceptional summer heat in Eastern Europe, including Ukraine and western Russia,[46,47] particularly the severity and duration of extreme heat in Russia. Wheat yields fell by around one third.[48,49] At the same time, unprecedented rainfall and resulting flooding of the Indus river in Pakistan in 2010 affected the lives and livelihoods of 20 million people. Evidence suggests that these events were linked, and more likely due to climate change.[50] To maintain local food supplies, Russia imposed an export ban. Uncoordinated responses from other countries, driven by internal politics and national self-interest,[51] led to rapid price inflation on global markets.[52] Both panic buying and speculation contributed to the food price increases.[53]

In developing countries, low-income group responses included reducing (by necessity) food intake and expenditure, as well as participating in demonstrations. As citizens often identified the causes of food price inflation and shortages as attributable to politicians and big business, and their disregard for the needs of the poor,[54] food-related civil protests and unrest were sparked across multiple countries.[55]

43 Wright (2011), 'The economics of grain price volatility'.
44 Spiegel International (2008), 'Global Food Crisis: The Fury of the Poor'.
45 Challinor, A. J. et al. (2018), 'Transmission of climate risks across sectors and borders', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376, https://doi.org/10.1098/rsta.2017.0301.
46 Barriopedro, D. et al. (2011), 'The Hot Summer of 2010: Redrawing the Temperature Record Map of Europe', *Science*, 332(6026), doi:10.1126/science.1201224.
47 Hirabayashi, Y. et al. (2013), 'Global flood risk under climate change', *Nature Climate Change*, 3(9), doi:10.1038/nclimate1911.
48 Marchand, P. et al. (2016), 'Reserves and trade jointly determine exposure to food supply shocks', *Environmental Research Letters*, 11(9), doi:10.1088/1748-9326/11/9/095009.
49 Wegren, S. K. (2013), 'Food Security and Russia's 2010 Drought', *Eurasian Geography and Economics*, 52(1): pp. 140–156, doi:10.2747/1539-7216.52.1.140.
50 Mann, M. E. et al. (2017), 'Influence of Anthropogenic Climate Change on Planetary Wave Resonance and Extreme Weather Events', *Scientific Reports*, 7(1), doi:10.1038/srep45242.
51 Jones, A. and Hiller, B. (2017), 'Exploring the dynamics of responses to food production shocks', *Sustainability*, 9(6), doi:10.3390/su9060960.
52 Welton, G. (2011), 'The Impact of Russia's 2010 Grain Export Ban', Oxfam International, https://www.oxfam.org/en/research/impact-russias-2010-grain-export-ban.
53 Spratt, S. (2013), 'Food price volatility and financial speculation', FAC Working Paper, https://www.future-agricultures.org/publications/working-papers-document/food-price-volatility-and-financial-speculation.
54 Hossain, N. and Green, D. (2010), *Living on a Spike: How is the 2011 food price crisis affecting poor people?*, Oxfam Research Reports, https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file_attachments/rr-living-on-a-spike-food-210611-en_4.pdf.
55 Natalini, D. et al. (2019), 'Global food security and food riots – an agent-based modelling approach', *Food Security*, 11 (5): pp. 1153–1173.

Many countries in East Africa and the Sahel, as well as the Middle East and North Africa, experienced food riots, among them Somalia, Sudan, Tunisia, Egypt, Algeria, Oman, Iraq, Uganda, and Syria.[56]

Not only are food riots widely understood to reduce the political stability of countries;[57] instability and unrest can also spread to other countries in an affected region.[58] There is some evidence that the 2010–11 food price spike was a factor that fuelled the Arab Spring uprisings, resulting in regional geopolitical instability.[59] The potential consequences for future regional and international security, arising from climate-induced food insecurity as well as other climate impacts, have recently been raised as a concern by experts from multiple disciplines.[60] There are fears that such impacts could lead to the rise of extremist groups, paramilitary intervention, organized violence, and conflict between people and states.[61]

Experts expressed concern over food security due to direct near-term climate impacts in East Africa and the Sahel, coupled with the increasing probability of climate induced synchronous multiple breadbasket failure:

First, when these vulnerable regions experience yield reductions or harvest failure due to climate, they are likely to turn increasingly to global and regional markets for imports. Second, as the probability of multiple breadbasket failure increases globally, countries in vulnerable regions are increasingly likely to experience inflated prices and lack of availability on global markets. This will exacerbate food insecurity at a time when these regions most require imports. Third, given the evidence that food crises can cause political instability, unrest and conflict, the global community should be concerned not only about increased demand on global markets during synchronous breadbasket failure periods, but also about the cascading security risks that may as a consequence arise both within and between countries.

Addressing socio-economic vulnerabilities (Table 2) provides a vital opportunity to minimize the potential for such cascading risks. Effective action could significantly decrease the likelihood that climate hazards will translate into falling crop yields, diminished food security and increased reliance on potentially strained global food markets.

For this reason, monitoring of socio-economic vulnerabilities needs to be improved, particularly in the areas of most concern – i.e. East Africa and the Sahel. Without such monitoring and subsequent action to reduce risks, the risks of near-term climate impacts will not only remain, but relentlessly increase over the next decade and beyond (Section 3.6).

* This case study also draws on Chatham House research separate to the expert elicitation described in this paper.

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56 Ibid.
57 Ibid.
58 Lagi, M., Bertrand, K. and Bar-Yam, Y. (2011), 'The Food Crises and Political Instability in North Africa and the Middle East', *SSRN Electronic Journal*, doi:10.2139/SSRN.1910031.
59 Goldstone, J. (2011), 'Understanding the Revolutions of 2011: Weakness and Resilience in Middle Eastern Autocracies', *Foreign Affairs*, 90(3): pp. 8–16, http://www.jstor.org/stable/23039402.
60 Quiggin, D., De Meyer, K., Hubble-Rose, L., Froggatt, A. (2021), *Climate change risk assessment 2021: The risks are compounding, and without immediate action the impacts will be devastating*, Research Paper, https://www.chathamhouse.org/sites/default/files/2021-09/2021-09-14-climate-change-risk-assessment-quiggin-et-al.pdf.
61 Ibid.

3.4 Specific hazard-impact pathways: migration and displacement

3.4.1 Impacts on migration and displacement at global level

At global level, climate-related migration and displacement of people was highlighted by the participating experts as the second most important near-term risk, after food insecurity, from climate change. Of all votes cast to identify critical global hazard-impact pathways, one in five was for hazard-impact pathways leading to migration and human displacement,[62] while half were for pathways leading to food insecurity (Figure 4). These two hazard-impact pathways are interconnected because of the secondary impacts that can occur: food insecurity may itself drive migration, while migration can give rise to shortages of agricultural sector workers, and changes in demand for a given food supply, thus creating or exacerbating food insecurity.

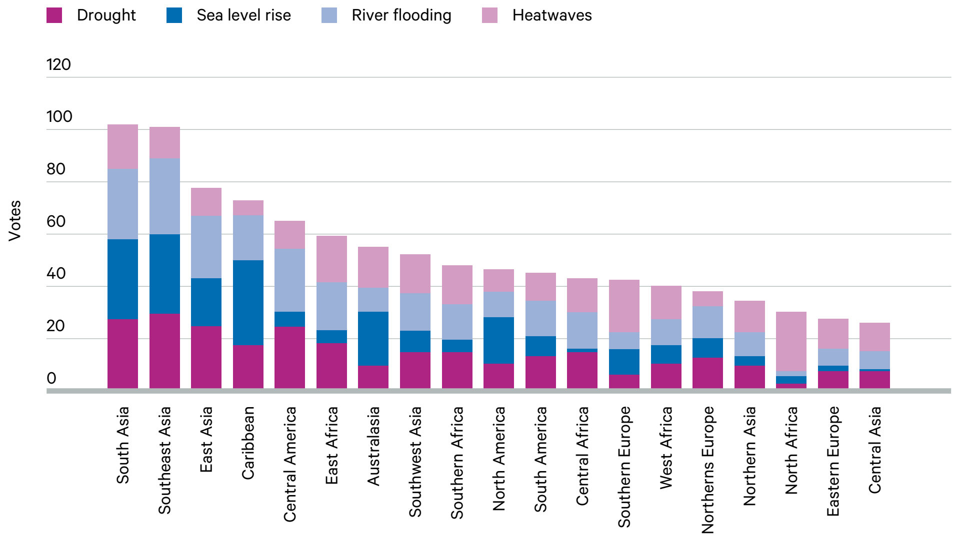
Drought, sea level rise, river flooding and heatwaves were identified as climate hazards that are likely to impact global migration and displacement in the near term. Geographically, the areas of greatest concern were South, Southeast and East Asia, the Caribbean and Central America. These five regions accounted for 42 per cent of the votes across the four identified climate hazards included in pathways leading to migration and displacement. (Regions of Africa were highlighted as being of concern within the category of continental – rather than global – migration and displacement.)

There is wide variation in the models of future sea level rise, depending on emissions scenarios and how these feed into ice melt (and the potential for tipping points to accelerate ice mass loss). There is therefore potential for sea level rise to accelerate in a non-linear manner.[63] Experts' views notably varied concerning when the major impacts of sea level rise are likely to occur. One expert considered that it is 'extremely unlikely non-linear sea level rise will occur within [the] 2030 time horizon', while another commented that 'flooding will be worsened by sudden increases in sea level'. Despite this, when given the option to downvote specific hazard-impact pathways within Round 2, sea level rise remained within the pathways of near-term concern. This is perhaps because sea level rise coupled with more frequent and lower-pressure storms (which can raise local sea level by a metre, plus intensifying wind effects to create storm surges) can increase flood risks markedly, and are factors already linked with migration and displacement.[64] A 1 metre rise in relative sea-level increases the probability of current 100-year flood events by around 40 times in Shanghai, around 200 times in New York, and around 1,000 times in Kolkata.[65]

62 86 votes of 421. Votes are aggregate of submissions and critical votes, with 'remove' votes taken away from the total.
63 Lindsey, R. (2021), 'Climate Change: Global Sea Level', NOAA Climate.gov, https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level.
64 Hauer, M. E. et al. (2019), 'Sea-level rise and human migration', *Nature Reviews Earth & Environment*, 1(1), doi:10.1038/s43017-019-0002-9.
65 King, D. et al. (2017), *Climate Change: A Risk Assessment*, https://www.csap.cam.ac.uk/media/uploads/files/1/climate-change--a-risk-assessment-v11.pdf.

Across the world, some 230 million people are living on land less than 1 metre above current high tide lines.[66] The long-term central estimate of committed sea level rise is around 12 metres, if average global temperatures are held at 2°C relative to pre-industrial levels. However, this could happen over a period of 500 years or 10,000 years: the timeframes are extremely uncertain.[67]

Figure 11. Global migration/displacement, initiated by hazards arising in regions (experts' responses)



Source: Chatham House expert elicitation exercise.

3.4.2 Impacts on migration and displacement at continental and regional level

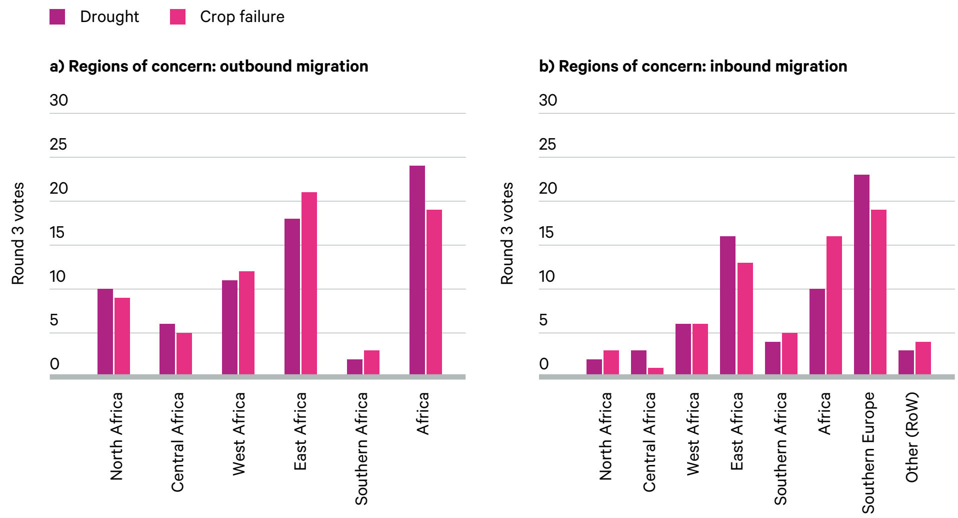
Independent of migration and displacement concerns at the global level, drought and crop failure is likely to lead to migration and displacement within and out of Africa. East Africa was identified by 25 per cent of votes in relation to drought, and 30 per cent concerning crop failure, as causes of outbound migration (Figure 12a). The experts identified Southern Europe as the principal long-term destination for people displaced by drought and crop failure in Africa, with 34 per cent and 28 per cent of votes, respectively, assigned to this region in relation to these pathways (Figure 12b).

One expert explained the sensitivity of drought and crop failure in East Africa to changing rainfall patterns:

> [The] inherent variability of the East African climate combined with the highly varied terrain and local climate heterogeneity means precipitation deviations from norms is quite high relative to other African regions.
> **Anonymized expert, Round 3**

66 Kulp, S. A. and Strauss, B. H. (2019), 'New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding', *Nature Communications*, 10(1), doi:10.1038/s41467-019-12808-z.
67 King et al. (2017), *Climate Change: A Risk Assessment*.

Figure 12. Regions of concern with regard to impacts of (a) outbound and (b) inbound migration and displacement of people due to hazards of drought and crop failure within Africa (experts' responses)



Source: Chatham House expert elicitation exercise.

Box 3. Case study: Migration and the cascading risk of political instability*

'Climate refugees' already account for more than a half of all migrants.[68,69] While it remains challenging to disentangle the factors that result in migration and displacement, the evidence that climate change is a contributing factor is mounting. Globally, every year since 2008, extreme weather (extreme heat, drought, floods, storms and wildfires) has resulted in an average of 21.8 million people being internally displaced.[70] Climate-induced food insecurity is also itself a driver of migration and displacement of people, alongside direct impacts from climate hazards that contribute to migration, such as droughts and flooding.

The majority of displacements of people are local – such as rural to urban, or away from the coast – and often temporary. However, climate change is increasingly resulting in long-term population movements, such as the movement of people working with grazing herds who have then moved into traditional pastoral land in the Sahel. Climate change can also lead to longer-term erosion of living conditions, and this can eventually trigger significant outward migration. For instance, as discussed in Box 2, there is evidence that the food price spike in 2010–11, first arising from droughts in Eastern Europe, was a significant factor in the regional geopolitical destabilization in the Middle East and North Africa that in turn became a factor driving migration out of North Africa into Europe. Some 13.4 million people in the Sahel were reported in 2020 as being

68 European Economic and Social Committee (2020), 'Climate refugees account for more than a half of all migrants but enjoy little protection', https://www.eesc.europa.eu/en/news-media/news/climate-refugees-account-more-half-all-migrants-enjoy-little-protection.
69 The factors that result in people choosing, or being forced to relocate their lives are numerous, and the evidence that a given climate impact is the principal driver is often contested.
70 Internal Displacement Monitoring Centre (2021), 'Global Internal Displacement Database', https://www.internal-displacement.org/database/displacement-data (accessed 12 Aug. 2021).

affected by drought and in need of humanitarian assistance.[71] In 2015, as the number of refugees and migrants entering Europe, having fled conflict in the Middle East and Africa, reached its highest point, at more than 1 million,[72] an equivalent number of people – some 1.1 million – were internally displaced by extreme weather events in sub-Saharan Africa alone.[73] In 2020 some 4.3 million people in sub-Saharan Africa were internally displaced because of extreme weather.[74]

Beyond the direct effects on the individuals leaving their homes, displacement and migration also have broader impacts on the outbound and inbound regions. Outbound regions are likely to suffer impacts such as the abandonment of land, declining agricultural yields, loss of skills, reduced contributions to GDP and a decline in socio-economic conditions,[75] to name only a few. The impacts for inbound regions depend on the capacity of the region to absorb and support incoming migrants, and the attitudes of the local population towards them. Impacts may include increased pressure on public services, infrastructure and resources such as drinking water, as well as rising societal tensions.[76] Evidence that political instability leads to reduced economic growth is broadly uncontested.[77] Some also point to evidence that higher immigration rates may increase political instability.[78]

What is often termed the European 'migrant crisis' of 2015 offers a lens through which to examine the inbound migration pressures that climate change may create,[79] as well as the potential for cascading impacts of political instability. During this period, EU member states engaged in dialogues with the European Commission on inbound migration. Yet as the 'crisis' progressed, divisions between member states and the Commission emerged, as a result of which the EU failed to agree a common migration and asylum policy. This impasse was partially due to member states wanting to protect their own interests above those of others. One example of this is member states' lowering their own official development assistance (ODA) allocations, on the basis that costs for hosting refugees are taken from these budgets,[80] a development that the then president of the European Commission, Jean-Claude Juncker, described as 'scandalous'.[81]

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71 UNHCR (2020), 'Sahel Crisis Explained', https://www.unrefugees.org/news/sahel-crisis-explained; Watts, N. et al. (2021), 'The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises', *The Lancet*, 397(10269), doi:10.1016/S0140-6736(20)32290-X; CRED & UNDRR (2021), '2020: The non-COVID Year in Disasters', https://reliefweb.int/report/world/2020-non-covid-year-disasters-global-trends-and-perspectives.
72 UNHCR (2021), 'Operational Data Portal', https://data2.unhcr.org/en/situations/mediterranean (accessed 12 Aug. 2021).
73 Internal Displacement Monitoring Centre (2021), 'Global Internal Displacement Database'.
74 Ibid.
75 KC, B. and Race, D. (2019), 'Outmigration and Land-Use Change: A Case Study from the Middle Hills of Nepal', *Land,* 9(1), https://doi.org/10.3390/land9010002.
76 Breulmann, M., Müller, R. A., Al-Subeh, A. and van Afferden, M. (2021), 'Influx of Syrian Refugees in Jordan | Effects on the Water Sector', https://reliefweb.int/report/jordan/influx-syrian-refugees-jordan-effects-water-sector.
77 Gebremedhin, T. A. and Mavisakalyan, A. (2013), *Immigration and political stability,* https://www.oecd.org/dev/pgd/46923664.pdf.
78 Ibid.
79 Whether or not climate change plays a role in creating these inbound migration pressures.
80 SEEK Development (2017), 'Understanding the impact of the refugee crisis on European donors' development budgets', https://donortracker.org/sites/default/files/donor_pdfs/17-05-30_Donor%20Tracker_Impact%20of%20refugee%20crisis%20on%20ODA.PDF.
81 Salazar, J. (2017), 'The EU's Internal and External Responses to the European Immigration Crisis', *Global Societies Journal*, 5.

During the 'crisis', countries such as Slovakia and Hungary became increasingly reluctant to support or even recognize the EU-wide quota system for refugees and asylum seekers, fearing large influxes of immigrants would disrupt the stability of their labour markets. Some member states implemented additional border controls.[82] Such responses should not only be viewed as a direct reaction to inbound migration; they were also a reaction to domestic popular opinion about migration. Many have argued that societal perceptions that a government is unable to secure its borders can lead societies to seek new forms of political power, out of a sense of necessity.[83] Given this, there is little wonder that many political commentators have connected immigration with the rise of populism and far-right political parties in Europe.[84]

Results from a regular survey on EU member states' citizens' attitudes towards migrants from poorer countries were published in 2019.[85] The proportion of respondents indicating they would unconditionally reject arrivals declined from 15 per cent in 2014/15 to 10 per cent in 2016/17, with individuals who felt themselves 'politically disempowered, financially insecure and without social support … most likely to develop extremely negative attitudes towards migrants'. The survey also found that individuals 'who place more importance on security tend to have the most negative attitudes towards migration'.[86] Overall, then, EU citizens' attitudes towards immigration appeared to be decreasingly hostile over the survey period. However, the evidence suggested around one in 10 Europeans still believed their country should reject migrants from poorer countries outright.[87]

* This case study has been developed through Chatham House desk research, separate to the expert elicitation described in this paper.

3.5 Specific hazard-impact pathways not mediated through food or human displacement

The expert elicitation highlighted four further global pathways (Figure 4) and three further continental pathways (Figure 6) as of consensus near-term concern. These pathways culminate in impacts of coastal flooding, public health crises and ecosystem/species loss at global level, in conflict and loss of livelihoods or income at continental level, and in infrastructure loss and damage at both global and continental levels.

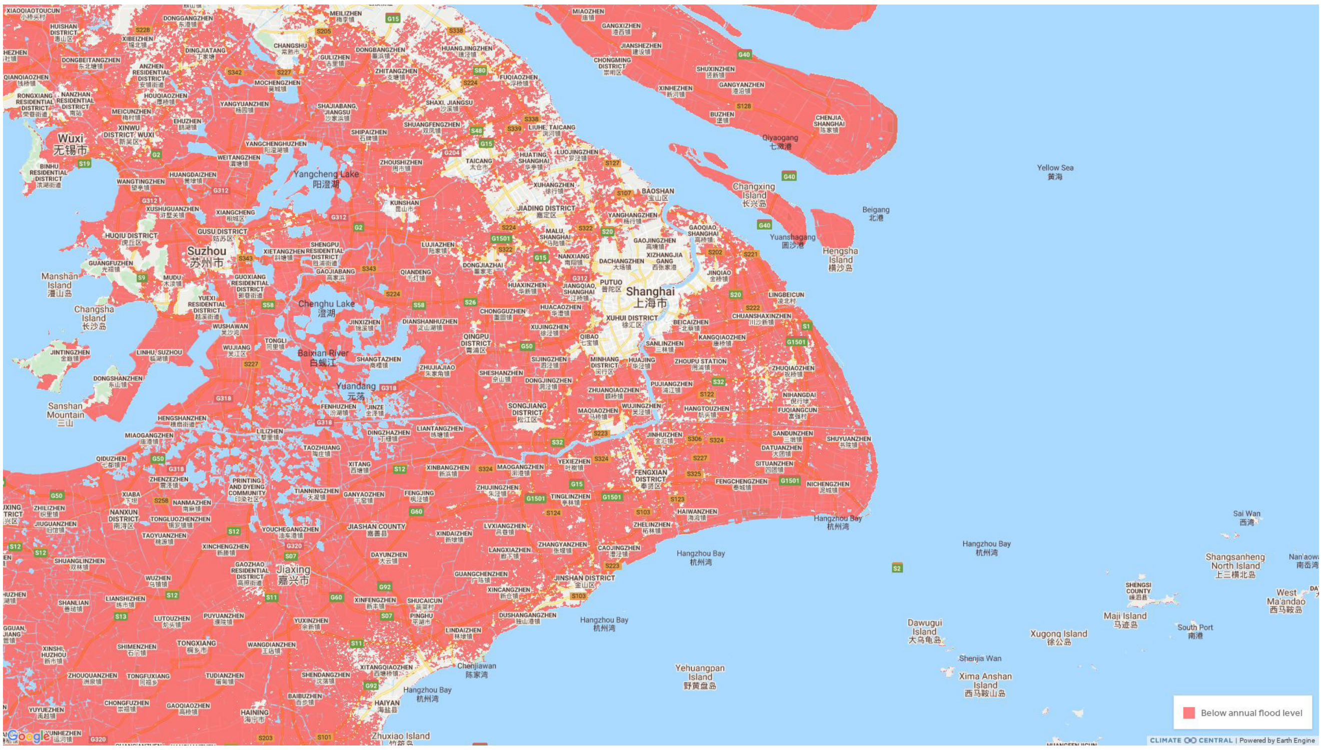
82 Ibid.
83 Gebremedhin and Mavisakalyan (2013), *Immigration and political stability*.
84 Modebadze, V. (2019), 'The refugee crisis, Brexit and the rise of populism: major obstacles to the European integration process', *Journal of Liberty and International Affairs*, 5(1): pp. 86–95, https://nbn-resolving.org/urn:nbn:de:0168-ssoar-63152-8; Iocco, G., Cascio, M. and Perrotta, D. C. (2020), "Close the Ports to African Migrants and Asian Rice!': The Politics of Agriculture and Migration and the Rise of a 'New' Right-Wing Populism in Italy', *Sociologia Ruralis*, 60(4), doi:10.1111/SORU.12304; Noury, A. and Roland, G. (2020), 'Identity Politics and Populism in Europe', Annual Review of Political Science, https://doi.org/10.1146/annurev-polisci-050718-033542; Burrell, K. and Hopkins, P. (2020), 'Introduction: Brexit, race and migration', *Environment and Planning C: Politics and Space*, 37(1), https://doi.org/10.1177/0263774X18811923a.
85 Messing, V. and Ságvári, B. (2019), 'Still divided but more open – Mapping European attitudes towards migration before and after the migration crisis', https://ec.europa.eu/migrant-integration/librarydoc/still-divided-but-more-open-mapping-european-attitudes-towards-migration-before-and-after-the-migration-crisis.
86 Ibid.
87 Ibid.

3.5.1 Hazard-impact pathways not related to food or human displacement

Global impacts from sea level rise

Coastal flooding due to sea level rise received an aggregate of 34 votes. As discussed in Section 3.4.1, climate models currently provide varying projections for the trajectory of sea level rise in future, although within the near-term time frame (i.e. to 2030) sea level rise is likely to remain incremental. Nonetheless, any sea level rise, in combination with storm surges that may become larger due to increased storm intensity, is a cause for concern. The Delphi process identified coastal flooding with the potential for global impacts originating in East Asia, Australasia and Southeast Asia (Figure 15a).

Figure 13. 2030 projected sea levels in and around Shanghai, based on a scenario of moderate cuts to pollution, and using the Leading Consensus sea level projection (IPCC 2021)



Source: Climate Central Coastal Risk Screening tool.[88]

For example, Figure 13 shows 2030 sea level rise and annual flood projections for Shanghai, one of the world's most populous cities and busiest ports. Any significant event (perhaps a combination of extreme rainfall causing the Yangtze river to flood, coupled with a storm and increased coastal flooding) impacting Shanghai would interrupt the flow of goods in and out of the port, leading to globally significant disruption of supply chains.[89]

88 Climate Central (2021), 'Land projected to be below tideline in 2030', https://coastal.climatecentral.org/map/8/121.2258/31.3724/?theme=sea_level_rise&map_type=year&basemap=roadmap&contiguous=true&elevation_model=best_available&forecast_year=2030&pathway=rcp45&percentile=p50&refresh=true&return_level=return_level_0&slr_model=kopp_2014 (accessed 30 Sept. 2021).
89 Climate Change Committee (2021), 'Independent Assessment of UK Climate Risk: Advice to Government For the UK's third Climate Change Risk Assessment (CCRA3)', https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk.

Global impacts from storms

Near-term global infrastructure loss and damage due to storms was also raised as a concern. Local infrastructure damage clearly undermines local societies by disrupting the flow of goods, people and/or information, as well as through the economic costs incurred. Significant infrastructural damage around key areas – such as manufacturing facilities and/or transport infrastructure – also has the potential to create cascading risks through interruption of supply chains (see Box 4). The regions where such damage may occur, particularly from storms, with associated global significance were identified as East and Southeast Asia, North and Central America, and the Caribbean (Figure 15b), together accounting for 66 per cent of votes in Round 3. It should be noted that the participating experts also identified significant concern regarding regional infrastructure loss and damage due to storms originating in and impacting South Asia (Section 3.5.2).

Box 4. Case study: Storm damage to infrastructure in Asia, impacting global supply chains*

In September 2018 Typhoon Mangkhut caused severe damage and disruption across Southeast and East Asia and beyond; its direct impacts were felt across territories including the Philippines, Malaysia, Taiwan, Hong Kong, Macau, southern China, Vietnam and Guam. In south China alone, some 2.45 million people had to be evacuated for their safety.[90] Some $3.77 billion of damaged was caused, and over 130 people lost their lives.[91]

Attribution of extreme weather events to climate change is challenging, and tropical cyclones are no exception.[92] Large fluctuations in the intensity and frequency of tropical cyclones compounds these difficulties, with studies demonstrating conflicting results.[93] However, climate models indicate the most intense cyclones are likely to substantially increase in frequency with climate change, with significant (20 per cent) increases in precipitation rates within 100 km of the centre of the storm.[94]

Increasingly in recent years, governments and infrastructure operators have been warned about the fragility of many forms of infrastructure. The power and transport sectors are perhaps the most vulnerable,[95] with both direct and indirect associated risks from climate hazards. For instance, power outages can be brought about by a power plant being flooded directly, or by the network infrastructure itself failing as power lines are brought down by high winds or flooding. This is precisely what happened during Typhoon Mangkhut in China. On the Guangdong power grid, six 10 kV towers, thousands of pylons, over 700 km of cable lines and 33 distribution

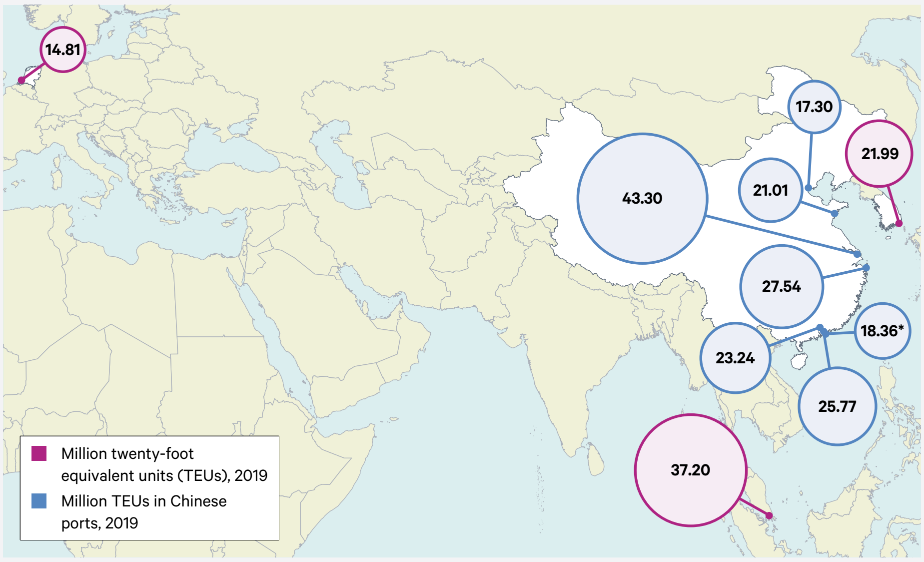
90 XinhuaNet (2018), 'Super Typhoon Mangkhut lands on south China coast', 16 September 2018, http://www.xinhuanet.com/english/2018-09/16/c_137471874.htm.
91 Knutson, T. et al. (2020), 'Tropical cyclones and climate change assessment part II: Projected response to anthropogenic warming', *Bulletin of the American Meteorological Society*, 101(3), doi:10.1175/BAMS-D-18-0194.1.American Meteorological Society.
92 Moon, I. J. et al. (2019), 'Climate change and tropical cyclone trend', *Nature*, 570(7759), doi:10.1038/s41586-019-1222-3.
93 Knutson, T. R. et al. (2010), 'Tropical cyclones and climate change', *Nature Geoscience*, 3(3), doi:10.1038/ngeo779.
94 Ibid.
95 Woetzel, J. et al. (2020), 'Will climate change cause infrastructure to bend or break?' McKinsey Sustainability, 19 August 2020, https://www.mckinsey.com/business-functions/sustainability/our-insights/will-infrastructure-bend-or-break-under-climate-stress.

transformers were damaged.[96] The causes identified included soft soil due to rainfall causing cable poles to tilt and collapse, wind speeds exceeding design thresholds, and damage due to landslides.[97]

Not only did 13 locations experience blackouts,[98] but transport was shut down across southern China,[99,100] and in Hong Kong alone more than 800 international flights were cancelled or delayed, with more than 100,000 passengers affected.[101]

International shipping was also impacted, with Hong Kong and Shenzhen ports closed for three days, and full operations only restored after several more days.[102] Both these ports are integral to global trade and supply chains: in 2017 Hong Kong was the third largest container ship port globally, and Shenzhen the fifth largest. As illustrated in Figure 14, nine of the world's 10 biggest ports, by volume handled, are located in Southeast and East Asia.[103] In total, more than 200 container ships were 'considerably delayed' by the impacts of Typhoon Mangkhut.[104]

Figure 14. The 10 largest ports globally, by volume handled (in TEUs), 2019



* Hong Kong SAR.

96 Zhong, L. et al. (2019), 'Damage Analysis of Distribution Network in Super Typhoon Mangkhut', *Procedia Computer Science*, 155: pp. 822–827, doi.org/10.1016/j.procs.2019.08.121.
97 Ibid.
98 *Shenzhen Daily* (2018), 'Mangkhut wreaks havoc on SZ', 17 September 2018, https://web.archive.org/web/20180917082333/http://www.szdaily.com/content/2018-09/17/content_21086105.htm (accessed 21 Jul. 2021).
99 BBC News (2018), 'Typhoon Mangkhut: South China battered by deadly storm', 17 September 2018, https://www.bbc.co.uk/news/world-asia-45543664.
100 Huifeng, H. and Zhang, P. (2018), 'Southern China's Pearl River Delta shuts down as Typhoon Mangkhut kills at least two in Guangdong', *South China Morning Post*, 16 September 2018, https://www.scmp.com/news/china/article/2164434/southern-chinas-pearl-river-delta-region-shuts-down-typhoon-mangkhut.
101 BBC News (2018), Typhoon Mangkhut: South China battered by deadly storm.
102 Wang, K., Yang, H. and Zhang, A. (2020), 'Seaport adaptation to climate change-related disasters: terminal operator market structure and inter- and intra-port competition', *Spatial Economic Analysis*, 15(3): pp. 311–355, doi: 10.1080/17421772.2019.1708443.
103 Globely News (2020), 'These Are the World's Largest Ports', 22 November 2020, https://globelynews.com/world/worlds-largest-ports.
104 Wang et al. (2020), 'Seaport adaptation to climate change-related disasters'.

While not a result of a tropical storm, similar disruption to global trade was experienced during the Yangtze river flooding of 2020, caused by the highest rainfall in 60 years in the affected area.[105] The authorities were forced to destroy a dam at risk of collapse,[106] which disrupted cargo ships down the river and within Shanghai port.[107] Critically, exports of personal protective equipment for health workers battling COVID-19 were delayed by the disruption caused by the Yangtze river flooding.[108] Significant disruptions to global trade expose countries that rely on certain goods to risks; and, where goods are essential – such as food – the economically marginalized are most vulnerable to shortages.

The principal vulnerability of large global shipping ports is their coastal location, meaning options to increase resilience are limited. The UN Conference on Trade and Development (UNCTAD) has called for 'accurate information, including climate and socio-economic data at the local level', stating that this 'is a pre-requisite for informed decision making and well-designed and effective adaptation response measures'.[109] Compiling such information is clearly essential given that 80 per cent of global trade is ocean based,[110] and as Figure 14 illustrates, there is concentration of port dependency in Southeast and East Asia, where experts predict impacts from storms will be greatest in the near term.

* This case study has been developed through Chatham House desk research, separate to the expert elicitation described in this paper.

Global impacts from heatwaves

The participating experts also identified heatwaves of global significance as a key near-term hazard. Heatwaves causing health crises – particularly through heat exposure – globally were seen as likely to occur across a fairly even spread of subcontinental regions (Figure 15c). Heatwaves leading to globally significant ecosystem, habitat and species loss (Figure 15d) were seen as most likely to originate within South America, Australasia and sub-Saharan Africa.

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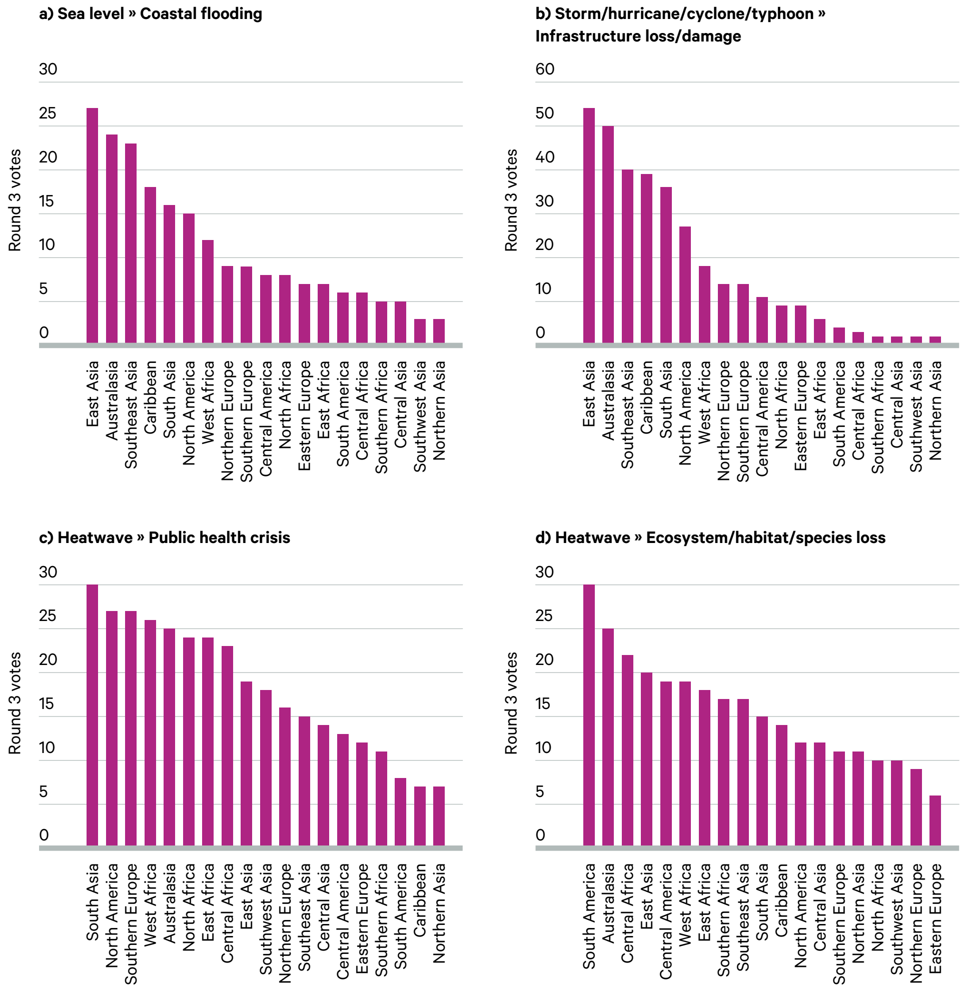
105 Guo, Y. et al. (2020), 'Floods in China, COVID-19, and climate change', *The Lancet Planetary Health*, 4(10): pp. 443–444, doi:10.1016/S2542-5196(20)30203-5.
106 Piesse, M. (2020), 'Floods in China Threaten Supply Chains for Critical Goods', Future Directions International, 22 July 2020, https://www.futuredirections.org.au/publication/floods-in-china-threaten-supply-chains-for-critical-goods.
107 Far East Cargo Line (2020), 'Floods in China disrupt Yangtze River cargo flow', https://www.fecl.co.uk/news/79.
108 Kelly, P. (2020), 'Floods disrupting PPE and critical supply chains', Norman Global Logistics, 29 July 2020, https://www.normanglobal.com/floods-disrupting-ppe-and-critical-supply-chains/?web=1&wdLOR=c0A13D337-4B90-4D6D-A8CC-5B24753E061B.
109 Asariotis, R., Benamara, H. and Mohos-Naray, V. (2017), *Port Industry Survey on Climate Change Impacts and Adaptation*. https://unctad.org/system/files/official-document/ser-rp-2017d18_en.pdf.
110 Monioudi, I. N. et al. (2018), 'Climate change impacts on critical international transportation assets of Caribbean Small Island Developing States (SIDS): the case of Jamaica and Saint Lucia', *Regional Environmental Change,* 18 2211–2225, https://doi.org/10.1007/s10113-018-1360-4.

Figure 15. Other global hazard-impact pathways, identifying the region in which the hazard occurs (experts' responses)



Source: Chatham House expert elicitation exercise.

Box 5. Case study: Heatwaves and changing weather patterns leading to pests and diseases*

Emerging infectious diseases and vector-borne diseases, as well as the rise of pests, were not among the top-ranked hazard-impact pathways identified by the group of participating experts in the survey rounds. During the workshops, however, the experts did identify the need to highlight these risks to human health and food security.

Climate change disrupts ecosystems and increases the risks of diseases jumping to new hosts.[111] Scientists have been warning for many years of the probability of pandemics increasing as a result of climate change.[112] In 2008, a study published in the journal

111 Brooks, D., Hoberg, E. and Boeger, W. (2019), *The Stockholm Paradigm: Climate Change and Emerging Disease*, Chicago, IL: The University of Chicago Press.
112 Curseu, D. et al. (2010), 'Potential Impact of Climate Change on Pandemic Influenza Risk', *Green Energy and Technology*, 31, doi:10.1007/978-1-4419-1017-2_45.

Nature found that over the previous decade nearly one third of emerging infectious diseases were vector-borne, with the jumps to humans corresponding to changes in the climate. For instance, insects such as infection-bearing mosquitoes follow changing geographic temperature patterns.[113] In parallel research conducted at Chatham House,[114] experts identified an amplifying cascade of climate risks. Changing weather patterns are likely not only to decrease crop yields and lead to the displacement of people, but also to alter ecosystems. This can in turn lead to an increased prevalence of pests disrupting crops in new areas, as well as emerging infectious and vector-borne diseases as humans and pests (and also animals) interact in new ways, compounding the impacts of food insecurity and displacement of people.

* This case study has been developed through Chatham House desk research, and an expert elicitation exercise separate to that described in this paper.

Box 6. Case study: The crucial role of vulnerable energy infrastructure during heatwaves*

One of the key considerations highlighted by the expert elicitation process described in this paper was the role of energy supply in mitigating extreme heat. There was recent clear evidence of this in the North American heat dome in July 2021, in which extreme heat triggered electricity blackouts and thus impaired the capacity for cooling through air conditioning.[115] This extreme heat event also had more direct public health impacts, with one public health officer in Oregon describing conditions as 'life-threatening heat'.[116] The *Guardian* reported: 'The intense and unrelenting heat is believed to have killed as many as 500 people in the province of British Columbia and contributed to the hundreds of wildfires currently burning across the province.'[117]

Such crises could be due to the direct impacts of heat on electricity infrastructure, and indirect impacts on infrastructure such as wildfires damaging power lines. These impacts lower energy security at times of increased reliance on air conditioning during heatwaves. For many populations across the world, lack of exposure to previous heat events may mean a lack of investment in air conditioning. A lack of economic access across the developing world means exposure to the direct impacts of heat without the possibility of cooling.

Experts also touched on the compounding impact of heatwaves occurring concurrently with around public health emergencies of international concern (such as the COVID-19 pandemic), in which vulnerable energy infrastructure could exacerbate the direct impacts

113 Jones, K. E. et al. (2008), 'Global trends in emerging infectious diseases', *Nature*, 451(7181): pp. 990–993, doi:10.1038/nature06536.
114 Quiggin et al. (2021), *Climate change risk assessment 2021*.
115 Sullivan, B. and Chediak, M. (2021), 'Northwest Heat Wave Triggers Blackout as New York Will Sizzle', Bloomberg, 29 June 2021, https://www.bloomberg.com/news/articles/2021-06-29/northwest-heat-wave-triggers-blackout-with-u-s-east-due-to-boil.
116 Olmos, S. (2021), 'Intense heat wave blisters U.S. Northwest with record temperatures', Reuters, 28 June 2021, https://www.reuters.com/article/uk-usa-weather-heatwave-idUKKCN2E407S.
117 Cecco, L. (2021), ''Heat dome' probably killed 1bn marine animals on Canada coast, experts say', *Guardian*, 8 July 2021, https://www.theguardian.com/environment/2021/jul/08/heat-dome-canada-pacific-northwest-animal-deaths.

of heatwaves and compound mortality. Energy supplies are both particularly vital and particularly vulnerable during heatwaves. During the COVID-19 pandemic, electricity has been vital in the operations of health services, including for the mechanical ventilation of critically ill patients.[118] The context of the pandemic also created the need for special considerations when establishing cooling centres in the North American heat dome of mid-2021, to prevent exacerbating the spread of the virus.[119]

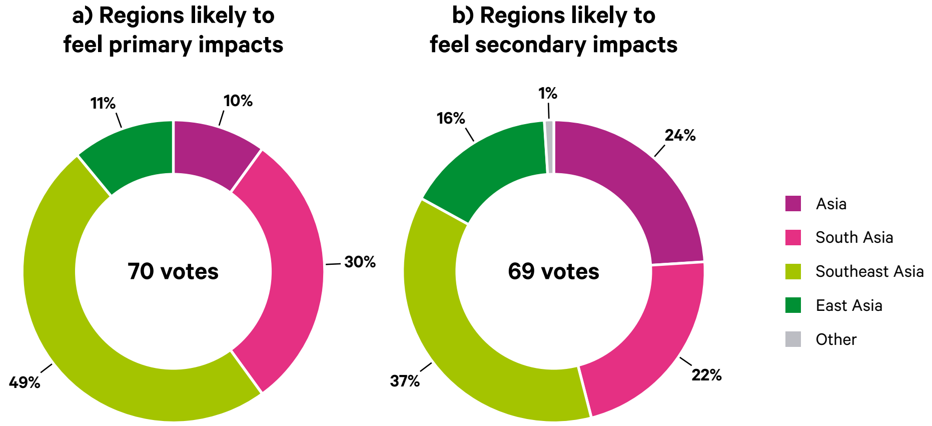
* This case study has been developed through Chatham House desk research, separate to the expert elicitation described in this paper.

3.5.2 Hazard-impact pathways not related to food or human displacement at continental and regional levels

Storm damage to infrastructure in Asia

While the impact of infrastructure loss and damage in Asia can have global significance due to the ability to interrupt supply chains (Section 3.5.1 and Box 4), the localized impacts of such events within the region is important: disrupting livelihoods, threatening lives and creating large-scale economic losses. As can be seen in Figure 16a&b, experts considered that Southeast and South Asia were likely to suffer near-term primary impacts from such climate hazards, with secondary impacts also concentrated in the same regions. East Asia was also flagged, but with lower concern in relation to primary impacts (Figure 16a), and slightly higher concern regarding secondary impacts (Figure 16b).

Figure 16. Regions where cyclones and typhoons are likely to suffer (a) primary and (b) secondary climate change impacts in Asia (experts' responses)



Source: Chatham House expert elicitation exercise.

118 Bryce, R. (2020), 'Beating Covid Is All About Electricity', Forbes, https://www.forbes.com/sites/robertbryce/2020/04/19/beating-covid-is-all-about-electricity/?sh=6498688250b8.
119 Global Heat Health Information Network (2020), 'How should cooling centres be managed during the COVID-19 pandemic?', updated 17 May 2020, https://ghhin.org/faq/how-should-cooling-centres-be-managed-during-the-covid-19-pandemic.

Box 7. Case study: Storm damage to infrastructure in Asia*

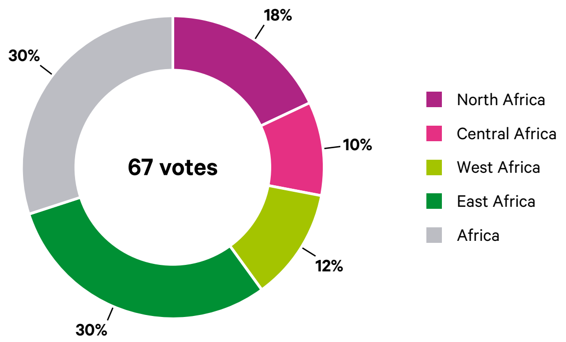
In the summer months of 2021 there was significant storm damage to infrastructure in China, arising from prolonged periods of very intensive rainfall. In parts of Henan Province in China, more than an average year's worth of rain fell in under five days, and the capital, Zhengzhou, received the equivalent of half its annual average rainfall in just six hours.[120] At least 25 people were reported to have been killed in the flooding, including 12 people in Zhengzhou after passengers were trapped in rising waters of flooded underground railway tunnels.[121] There was widespread further damage to infrastructure, and some 200,000 residents had to be evacuated to safety. With more than a dozen cities affected, President Xi Jinping said there had been 'significant loss of life and damage to property'.[122] Emergency measures to limit potentially devastating further damage included the forced demolition of part of the Yihetan dam at Luoyang – a city of approximately 7 million people – to prevent its collapse,[123] which authorities were concerned may be imminent.[124]

* This case study has been developed through Chatham House desk research, separate to the expert elicitation described in this paper.

Drought leading to conflict in Africa

Climatological drought was identified by the participating experts as a potential contributor to conflict and an important near-term concern in Africa. Clearly a prime proximal route for this pathway is through drought's impact on food and water security, as well as through consequences for human displacement. Again, East Africa was the region of greatest concern, accounting for 30 per cent of Round 3 votes (Figure 17).

Figure 17. Drought leading to conflict in Africa (experts' responses)



Source: Chatham House expert elicitation exercise.

120 World Meteorological Organization (2021), 'Water-related hazards dominate disasters in the past 50 years', 23 July 2021, https://public.wmo.int/en/media/press-release/water-related-hazards-dominate-disasters-past-50-years.
121 Al Jazeera (2021), 'Central China: 25 dead in flooded Zhengzhou metro, landslides', 20 July 2021, https://www.aljazeera.com/news/2021/7/20/army-issues-dam-warning-deadly-storm-hits-china.
122 BBC News (2021), 'China floods: 12 dead in Zhengzhou train and thousands evacuated in Henan', 21 July 2021, https://www.bbc.co.uk/news/world-asia-china-57861067.
123 Associated Press via NPR (2021), 'China Blasts Dam To Divert Massive Floods In Henan Province', https://www.npr.org/2021/07/21/1018764692/china-blasts-dam-to-divert-massive-flooding-that-has-killed-at-least-25?t=1627381995163&t=1627990725493.
124 Al Jazeera, 'Central China: 25 dead in flooded Zhengzhou metro, landslides'.

3.6 Addressing socio-economic vulnerabilities is in all countries' collective interest

Global cascading climate risks (in which a climate hazard in one place may trigger impacts that cascade and amplify across nations and borders) are increasingly of near-term concern.[125,126,127,128] The prevalence of such cascades, and the complexities of mapping the regional and global interdependences through which such cascades are transmitted, means one country's vulnerability and exposure is potentially many countries' or indeed every country's concern. The case studies presented in Boxes 2–4 describe some of the potential risks of such cascades, and their interplay with vulnerable regions of concern.

Wealthy nations, global leaders, multilateral development finance institutions and the private sector all have a clear stake in addressing the socio-economic vulnerabilities that are likely to lead to regional or global political and security instability.

Wealthy nations, global leaders, multilateral development finance institutions and the private sector all have a clear stake in addressing the socio-economic vulnerabilities (summarized in Table 2) that are likely to lead to regional or global political and security instability (as explored in Box 3), as well as addressing the supply-chain risks inherent in the examples in Box 4. Table 2 summarizes the critical socio-economic vulnerabilities – as identified by the experts who participated in the elicitation process that has informed this paper – likely to amplify the impact of climate hazards within the three categories of hazard-impact pathways presented in the previous sections. These vulnerabilities exist at global, continental and regional levels. Regional vulnerabilities are centred around East Africa and the Sahel, as well as South Asia. Many of the socio-economic vulnerabilities that are identified within Table 2 as likely to amplify the impacts of climate hazards on food insecurity are also expected to amplify the impacts on human migration and displacement.

125 Lawrence, J. et al. (2020), 'Cascading climate change impacts and implications', *Climate Risk Management*, 29, doi:10.1016/J.CRM.2020.100234.
126 Challinor et al. (2018), 'Transmission of climate risks across sectors and borders'.
127 Cradock-Henry, N. A. et al. (2020), 'Elaborating a systems methodology for cascading climate change impacts and implications', *MethodsX*, 7, doi:10.1016/J.MEX.2020.100893.
128 Hilly, G. et al. (2018), 'Methodological framework for analysing cascading effects fromflood events: The case of Sukhumvit area, Bangkok, Thailand', *Water*, 10(1), doi:10.3390/W10010081.MDPI AG.

Table 2. Summary of socio-economic vulnerabilities (global, unless otherwise stated) likely to exacerbate near-term global and regional impacts of climate change, global and regional (*italics denote direct quotes from participating experts*)

Socio-economic vulnerabilities

Vulnerable conditions

Food security

- *Low income, low democratic accountability and transparency and weak governance*
- *Arid and semi-arid lands* [include] *important livestock production zones; sub-humid areas sustain a large community of subsistence farmers* [so displacement of livestock farmers into agrarian zones leads to conflict] (concerning East Africa and the Sahel)
- *Local systems of food production and consumption (subsistence agriculture and local markets)*
- *Economic decline and increased rural and urban poverty, urban expansion and economic stagnation increasing the urban poor*
- *Over-exploited water system and high population density, vulnerable due to poverty and reliance on domestic food supply* (concerning South Asia)
- *Large number of smallholder farmers relying on rain-fed agriculture as well as the multiple large dams across the region all exposed to drought at similar times* (concerning Africa)

Migration and displacement

- *Population growth and geographic concentration of population, agriculture and infrastructure. Political instability, armed conflict and mass immigration (either transnationally, or rural to urban).*

Other: Storms causing infrastructure damage

- [Global] *reliance on production sites located in these regions* [could lead to global cascading impacts on trade and pinch points in global supply chains]

Lack of resilience or adaptive capacity

Food security

- *Smallholder farmers unable to cope* [with impacts of climate change]
- *Adaptation is slow because of failure to adapt crops, farming techniques, and livelihoods to new climate conditions; and cropping systems that cannot adapt rapidly enough to changing conditions; and because adaptation is too expensive to be adopted at scale*
- *Weak institutional capacity to assist during food security crises*
- *Governments' lack of capacity to provide basic services, raise awareness about climate change, and promote adaptation and mitigation strategies*

Other: Storms causing infrastructure damage

- *High concentrations of population, infrastructure and assets in coastal areas, and in particular the large number of poor and marginalized people living in those areas with no resources to support adaptation and disaster risk reduction measures*

Existing fault lines (tensions that exacerbate competition for resources)

Food security

- *Conflict, terrorism, corruption, and associated abandonment of rural land*
- *Existing or potential tensions with other countries over natural resources is a key vulnerability*
- *Ethnic tensions*

Migration and displacement, and drought leading to conflict (particularly concerning East Africa and the Sahel)

- *Insecurity has been highly exacerbated in recent years, which is also contributing to growing internal migration, a new booster of uncontrolled concentration of people in urban areas* (concerning East Africa and the Sahel)

External reliance and interdependences

Food security

- *Countries* [overly] *reliant on regional/global markets for food imports* (see also Box 2)
- *High geopolitical tensions that could hamper effective disaster response* (concerning South Asia)

As illustrated in Table 2, the participating experts highlighted several interlinked vulnerabilities that may exacerbate the impact of climate risks as concerns food security (Figure 10), with interconnections to migration and displacement, and conflict in East Africa and the Sahel. Their potential impacts have an inherent possibility of initiating cascading risks that propagate out of the region. A particularly important area where vulnerabilities can be reduced is through agricultural adaptation. On average, just 5 per cent of the cultivated area within Africa is currently irrigated, compared with an average of 21 per cent globally.[129] This points to an opportunity to increase the resilience of food production. A 2019 review of National Communications[130] submitted by 21 African countries to the UNFCCC identified six thematic areas and 33 categories of climate change adaptation measures within the crop sector (Table 3).[131] These adaptation measures are a synthesis of measures identified by the vulnerable countries themselves, and therefore offer locally specific and relevant actions that clearly have buy-in from the administrations that will ultimately deliver them.

Implementation of such adaptation measures has, however, proved historically challenging. As one expert pointed out:

> In Sudan, for example, we see through our field projects that climate adaptation of farming and grazing is possible and offer good opportunities for peacebuilding too. However, there are challenges linked to the successful implementation of these interventions, such as geographic, political, economic, social, and cultural.
> **Anonymized expert, Round 3**

Table 3. Crop sector adaptation themes and categories, synthesized from National Communications submitted by 21 African countries to the United Nations Framework Convention on Climate Change (UNFCCC)

Adaptation themes and categories
Theme 1. Crop diversification, and disease and pest management
1. Production of a variety of crops
2. Crop varieties (including pest and disease-tolerant varieties)
3. Heat shock varieties
4. Indigenous varieties and salinity-resistant and short-season varieties
5. Changing cultivars
6. Changing crop patterns
7. Enhanced financial and technical support to drought-resistant (tolerant) crops
8. Disease and pest management

129 Borderon, M. et al. (2019), 'Migration influenced by environmental change in Africa: A systematic review of empirical evidence', *Demographic Research*, 41, doi:10.4054/DEMRES.2019.41.18.
130 A national communication is a report that each party to the UNFCCC prepares periodically in accordance with the guidelines developed and adopted by the Conference of the Parties (COP). It is a commitment to provide to the COP: A national inventory of anthropogenic emissions; a general description of implementation steps taken or envisaged; other information considered relevant to achieving the objectives of the Convention.
131 Muchuru, S. and Nhamo, G. (2019), 'A review of climate change adaptation measures in the African crop sector', *Climate and Development*, 11(10): pp. 873–885, doi:10.1080/17565529.2019.1585319.

Adaptation themes and categories

Theme 2. Water, irrigation and flood management

9. Improved irrigation
10. On-farm water management strategies
11. Water-use efficiency
12. Water pricing
13. Giving incentives to farmers to farm in basins
14. Providing artificial flooding and recharge of aquifers
15. Construction of de-silting dams
16. Sustainable groundwater use
17. Water conservation schemes

Theme 3. Land use, policies, alternative livelihoods and infrastructure development

18. Conservation agriculture (including promoting soil conservation schemes)
19. Alternative livelihoods (including bee-keeping)
20. Infrastructure development
21. Sound land tenure and land allocation

Theme 4. Market access, value addition and post-harvest matters

22. Market projections and changing markets
23. Inputs
24. Subsidies
25. Storage facilities (utilizing grain-specialized storage containers as well as increasing and upgrading post-harvests storage facilities)
26. Encouraging farmers to set up businesses for value chains and adding of agricultural produce and drying of fruit

Theme 5. Weather-based index insurance, information and early-warning systems

27. Weather-based index insurance
28. Early-warning systems (including quantitative projections of changes in rainfall; short-, medium- to long-term forecasting; as well as fostering floods and drought monitoring)
29. Information and extension work

Theme 6. Research, development and science communication

30. Agricultural research and dissemination
31. Creation of small agricultural and climatological stations
32. Communication by scientists to farmers
33. Farmers and other technical services

Source: Muchuru and Nhamo (2019).[132]

Vulnerabilities beyond agricultural production also need to be addressed to reduce the likelihood of climate hazards translating into food insecurity, and migration and displacement of people. Ensuring livelihoods are diversified, levels of poverty are reduced, and skilled jobs are created will all help to tackle inequalities,[133] and enable communities to continue to afford staple foods.[134] This is particularly important given that nearly 80 per cent of people in East Africa rely on agriculture for their income, and the agriculture sector provides 40 per cent of the region's

132 Ibid.
133 International Labour Office (2010), *A Skilled Workforce for Strong, Sustainable and Balanced Growth*, https://www.oecd.org/g20/summits/toronto/G20-Skills-Strategy.pdf.
134 Mensah, C. (2014), 'The impact of livelihood diversification on food security amongst farm households in northern Ghana: a case study of Bole district' (thesis).

GDP.[135] Furthermore, ensuring that governance institutions are strengthened in the region will aid these institutions' ability to deliver social security and welfare, increasing the region's ability to adapt and respond to climate impacts.[136] Indeed, addressing health and education provision and the ability to plan for the future, alongside tackling poverty and financial inequalities, often enhances the adaptive capacity of communities.[137]

Experts raised many concerns about security related to food, water and energy as well as conflict, terrorism, and societal and ethnic tensions. These issues are all complex and interact with climate change (and adaptation), and with pre-existing vulnerabilities that increase the risk of climate impacts: for example, a drought can exacerbate food insecurity, resulting in abandonment of land and human displacement, all of which can increase risks and tensions that result in more acute impacts. Conflict can also hinder climate change adaptation, as well as damaging or destroying key resources and infrastructure.[138] As such, adaptation measures should, at a minimum, not increase the risk of conflict, and should if possible enhance peacebuilding. It should be recognized that efforts to combine adaptation and peacebuilding require improved governance, security and economic growth, and – crucially – the buy-in of affected communities.[139]

Migration and human displacement themselves cause impacts for both the places that people flee from, and the places that people flee to (Box 3). As outlined in Box 3, immigration into Europe (in which climate may have played a role) has been a factor in the political instability Europe has witnessed over the last six years. Experts who contributed to the elicitation process that has informed this paper expressed concerns over the potential for near-term climate impacts to drive further increases in migration, particularly from Africa into Southern Europe. Given this concern, as well as the fact that political instability often leads to impaired economic growth, there is a clear case for addressing the socio-economic vulnerabilities summarized in Table 2. Doing so could offer a means to prevent or minimize cascading climate risks relating to migration. Steps would include addressing the issues that currently drive migration of vulnerable populations, and more effectively integrating immigrants into new communities and countries, which may require significant strengthening of governance institutions. Governments and the international community should therefore give particular attention to:

— Those vulnerabilities that translate climate hazards into food insecurity, which in turn drives migration. This involves a greater focus on climate-smart agriculture to build local resilience of food systems. As already noted, within Africa only 5 per cent of cultivated area is under irrigation, compared

135 Orindi, V. A. and Murray, L. A. (2005), 'Adapting to climate change in East Africa: a strategic approach', International Institute for Environment and Development, https://pubs.iied.org/9544iied.
136 IPCC: Parry, M. L, Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (eds) (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press; Tenzing, J. D. (2020), 'Integrating social protection and climate change adaptation: A review', *Wiley Interdisciplinary Reviews: Climate Change*, 11(2), doi:10.1002/WCC.626.
137 Ford, J. D. et al. (2015) 'The status of climate change adaptation in Africa and Asia', *Regional Environmental Change*, 15: pp. 801–814, doi:10.1007/s10113-014-0648-2.
138 Price, R. (2019), 'Climate change, vulnerability to violent extremism and conflict in Kenya', https://assets.publishing.service.gov.uk/media/5d9b4db740f0b607f3e67941/639_Climate_Change_and_Violence_in_Kenya.pdf.
139 Ibid.

with the global average of 21 per cent.[140] Many in-field adaptation measures already exist to improve the resilience of food production. Improving the uptake of agricultural adaptation measures appears to represent a key intervention for preventing cascades of climate impacts culminating in heightened migration.

- Those vulnerabilities that translate direct climate hazards more directly into drivers of migration, such as poverty and inequality, intercommunal tensions, gender inequalities, lack of access to education, and lack of alternative livelihoods in vulnerable communities and regions.

The expert elicitation process identified the vulnerability of global supply chains to critical port infrastructure damage due to storms in Asia in the near term. The concentration of port dependency in Southeast and East Asia, and limited ability to relocate ports, constrains the range of interventions available to reduce vulnerabilities. The findings of this research support UNCTAD's call for more accurate information on the risks and vulnerabilities to which ports are potentially exposed, as a 'pre-requisite for informed decision making and well-designed and effective adaptation response measures'.[141] International standard ISO 31000:2009 – *Risk management – Principles and guidelines* provided port authorities with the framework, principles and processes for managing risk.[142] A range of 'soft' and 'hard' measures exist,[143] including:

- Creating financial instruments to support adaptation
- Increasing standards of port construction to deal with higher winds
- Increasing breakwater dimensions
- Building new coastal defences
- Raising transport levels and port elevations
- Expanding dredging and nourishment programmes to handle increased quantity of sediment shifting
- Improving decision support tools and information
- Enhancing emergency evacuation plans

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140 Borderon et al. (2019), 'Migration influenced by environmental change in Africa'.
141 Asariotis et al. (2017), *Port Industry Survey on Climate Change Impacts and Adaptation*.
142 Becker, A. et al. (2017), 'Implications of climate change for shipping: Ports and supply chains', *Marine Affairs*, 9(2), doi:10.1002/wcc.508. Note that ISO 31000:2009 has since been superseded by ISO 31000:2018: see https://www.iso.org/standard/43170.html.
143 Becker, A. H. et al. (2013), 'A note on climate change adaptation for seaports: a challenge for global ports, a challenge for global society', *Climatic Change,* 120(4), doi:10.1007/S10584-013-0843-Z.

04 Conclusion and recommendations

Addressing, as a priority, socio-economic vulnerabilities in the countries and regions most likely to be impacted by climate risks between now and 2030 will be critical to averting or minimizing near-term global systemic climate risk cascades.

The impacts of climate change are now tangibly affecting societies around the world. The expert elicitation process described in this research paper highlights that even within the next decade, climate hazards are expected to have increasingly significant disruptive impacts. These impacts will not just play out locally in the path of the climate hazard, but form part of complex, interacting, cascading and compounding hazard-impact pathways which will create global impacts.

Given the concerns highlighted in this research, and the climate-related events of the first nine months of 2021, it is realistic to expect that climate impacts become more severe over the near term. Looking back over the last decade, we can see examples of many of the kinds of events that experts expect to see more of in the approach to the 2030s. Globally, each year in 2008–20, an average of 21.8 million people were internally displaced by weather-related disasters in the form of extreme heat, drought, floods, storms and wildfires.[144] In 2010–11, exceptional summer heat in Eastern Europe diminished wheat yields by a third, leading to severe global food price inflation, which was a factor in the unrest that sparked the Arab Spring uprisings which reverberated across the Middle East and North Africa. At the same time, unprecedented rainfall and resulting flooding in Pakistan affected the lives and livelihoods of some 20 million people.

144 Internal Displacement Monitoring Centre (2021), 'Global Internal Displacement Database'.

The research process described in this paper indicates that experts think climate risks will continue to be realized, and at accelerating pace and impact. Recent extreme weather adds urgency to the academic debate about the ability of climate impact models to comprehensively predict climate impacts.[145,146] This is particularly important given recent research highlighting the crucial way that resonance in planetary waves affects the jet stream and creates hemisphere-wide extremes.[147,148] There is an urgent need, recognizing the gap in understanding of how extremes may change, to quantify, track and manage climate risks. The fact that climate risks are not currently well characterized does not mean that we can afford to ignore them. The research reported in this paper is a first attempt, using expert elicitation, at least qualitatively, to assess the risks of greatest concern in the near term.

As the third UK climate change risk assessment points out: 'Adaptation action has failed to keep pace with the worsening reality of climate risk'.[149] Within the 2030 time horizon, socio-economic vulnerabilities are very likely to amplify the impacts caused by climate hazards. Such vulnerabilities within at-risk regions are not only likely to amplify the climate impacts in that region, but may act as cascade initiators, pushing impacts that then cascade across sectors and regions. Averting, or **minimizing near-term global systemic climate risk cascades therefore depends on addressing socio-economic vulnerabilities in the places most likely to be impacted by climate risks within the next decade**.

Global actors would be well advised, on the basis of this exercise, to consider what action can be taken to address vulnerabilities and avoid scenarios in which the most vulnerable regions become nexuses of cascading climate impacts over the next few years. The 10 hazard-impact pathways of greatest concern identified in this research all relate to Africa (eight pathways) or Asia (two pathways). The impacts of greatest concern are food security, migration and displacement of people, and conflict in Africa. These arise from multiple climate hazards: drought and changing rainfall patterns, coupled with heatwaves. East Africa and the Sahel, spanning West and East Africa, are identified as being of particular concern.

Food security concerns are not, however, confined to the African continent. Similar climate hazards, inclusive of flooding, were seen by the participating experts to be likely to impact South and Southeast Asia, and Australasia. There were concerns that storm damage to crops would exacerbate food security at the

145 Harrabin (2021), 'Climate change: Science failed to predict flood and heat intensity'.
146 Bartell (2021), 'Extreme weather takes climate change models 'off the scale''.
147 Jacob, C. and Reeder, M. (2021), 'The North American heatwave shows we need to know how climate change will change our weather', The Conversation, 2 July 2021, https://theconversation.com/the-north-american-heatwave-shows-we-need-to-know-how-climate-change-will-change-our-weather-163802.
148 Kornhuber et al. (2020), Amplified Rossby waves enhance risk of concurrent heatwaves in major breadbasket regions.
149 Climate Change Committee (2021), 'Independent Assessment of UK Climate Risk'.

global level. Experts expressed concern over multiple breadbasket failure at the global level, with the probability of such a failure[150] in the decade of the 2040s standing at just less than 50 per cent.[151,152]

Migration and displacement of people, stemming from similar climate hazards, were also of great concern to the participating experts. Impacts would be most felt in East Africa, South, Southeast and East Asia, the Caribbean and Central America. It was in East Africa and the Sahel where migration and displacement of people were of most concern, with drought and crop failure likely to drive 'climate refugees' into Southern Europe.

Further to the suffering and security concerns likely to stem from food shortage and migration impacts, drought was highlighted as a hazard likely to directly create the conditions for conflict across Africa, again concentrated in East Africa. Combined with changing rainfall patterns, drought is also likely to impact livelihoods and income across the African continent. At the same time, cyclones and typhoons in Southeast and South Asia were identified as likely to cause significant infrastructure loss and damage within the 2030 time horizon. Impacts within these regions could have global cascading impacts on international supply chains.

Building societal resilience to the shocks that are likely to occur is a form of adaptation. The 2015 Paris Agreement and 2018 Katowice climate package both call for all parties to undertake and document adaptation progress. Although there has been a rapid increase in the reporting of adaptation since 2006, availability and access to comprehensive socio-economic and adaptation data remains a pivotal challenge,[153] with data often unavailable.[154] Moreover, any meaningful datasets that do exist rarely contain comprehensive global coverage,[155] and are often subject to reporting biases.[156] Crucially, in those countries reporting adaptation measures, there is limited explicit recognition of the transboundary adaptations that are required to reduce risk cascades across geographies,[157] or of adaptations that address vulnerabilities across sectors.[158] New sources of data are required. These could include: publicly available reports, expert knowledge, legislation and regulations, digitally sourced big data, and crowdsourcing.[159] Equally important will be converging on common, systematic, longitudinal and comprehensive techniques

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150 The probability of a 10 per cent yield loss, or greater, within the top four maize producing countries (the US, China, Brazil and Argentina). These countries together account for some 87 per cent of the world's maize exports.
151 Tigchelaar et al. (2018), 'Future warming increases probability of globally synchronized maize production shocks'.
152 Converted Tigchelaar et al. (2018) temperature thresholds to timeframes, based on RCP4.5 passing relevant temperature thresholds, based on CMIP6 climate models. See https://esd.copernicus.org/articles/12/253/2021/esd-12-253-2021-discussion.html and https://www.carbonbrief.org/analysis-when-might-the-world-exceed-1-5c-and-2c-of-global-warming. Further, converted annual likelihood of 6.1 per cent to probability decadal probability of occurrence.
153 Lesnikowski, A. et al. (2015), 'National-level progress on adaptation', *Nature Climate Change* 6(3), doi:10.1038/nclimate2863.
154 Berrang-Ford, L. et al. (2019), 'Tracking global climate change adaptation among governments', *Nature Climate Change,* 9(6), doi:10.1038/s41558-019-0490-0.
155 Ibid.
156 Chen, C. et al. (2018), 'A global assessment of adaptation investment from the perspectives of equity and efficiency', *Mitigation and Adaptation Strategies for Global Change*, 23(1), doi:10.1007/S11027-016-9731-Y.
157 Carter et al. (2021), 'A conceptual framework for cross-border impacts of climate change'.
158 Ford et al. (2015), 'The status of climate change adaptation in Africa and Asia'.
159 Ford, J. D. et al. (2016), 'Opinion: Big data has big potential for applications to climate change adaptation', *Proceedings of the National Academy of Sciences of the United States of America*, 113(39): pp. 10729–10732, doi:10.1073/pnas.1614023113.

to track such data.[160] This research exercise constitutes proof of concept that using a Delphi method can generate expert consensus on risks that are not currently well attended to.

4.1 Recommendations

To reduce the likelihood of climate hazards materializing into impacts within vulnerable countries over the next decade, as well as minimize the chances of cascading impacts stemming from these countries, the international community, the governments of wealthy countries, investors, business leaders and academics need to work with vulnerable countries. Drawing on the insights gathered during the research that has informed this paper, the following recommendations are made to promote solid progress on common goals.

- This paper focuses on the need for effective adaptation measures. Despite this focus, our first and most important recommendation is for strong, unilateral mitigation action against climate change at and beyond COP26. The reason for this is that even if rapid action is taken to adapt to changing climate-related risks, the experts who contributed to the research process have emphasized the significant likelihood that we may soon be locked into impacts so severe they go beyond the limits of what nations can adapt to. The mitigation of climate change is thus of fundamental importance, requiring immediate, drastic and sustained reduction in greenhouse gas emissions and the preservation and restoration of natural carbon sinks.
- Adaptation measures are urgently needed, and must be prioritized, targeted and tailored. The focus must be on addressing socio-economic vulnerabilities in the regions most likely to suffer near-term climate impacts, and where conditions are already precarious.
- Action on adaptation in these regions should not be the concern only of these regions, but should be supported and enabled by richer nations. This support is in the near- and long-term interests of wealthy nations as it will not only avert worse impacts for the most vulnerable regions, but also help prevent the cascading impacts of food insecurity, migration and conflict that are likely to initiate subsequent impacts across borders and continents.
- Adaptation measures should, at a minimum, not increase the risk of conflict, and should where possible enhance peacebuilding. It should be recognized that efforts to combine adaptation and peacebuilding require improved governance, security and economic growth, and – crucially – the buy-in of affected communities.[161]

160 Biesbroek, R. et al. (2018), 'Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review', *Wiley Interdisciplinary Reviews: Climate Change*, 9(6), doi:10.1002/WCC.548.
161 Price (2019), 'Climate change, vulnerability to violent extremism and conflict in Kenya'.

- A comprehensive and up-to-date climate risk register[162] is needed, incorporating not only near-term climate impacts, but also socio-economic vulnerabilities and associated adaptations that reduce the overall risk, as well as disaster risk preparedness. International organizations, governments, civil society, academics and the private sector are all stakeholders in climate risk; and a clear understanding and ongoing monitoring of climate risk are needed to provide impetus and justification for action by governments, businesses and investors. Ongoing monitoring is also essential to adaptation planning and resilience. Only by improving the monitoring of risk and vulnerabilities can resilience and adaptation be robustly targeted and improved, and thus lessen climate impacts. Many experts, in this study and more widely, are suggesting that a UN body, such as the UN Security Council, should hold the proposed risk register.[163]

- There is a clear need for an annual assessment of how hazards, exposure and vulnerabilities are changing. Repeating this exercise, with modifications and improvements, would be valuable especially until more comprehensive systems for tracking emerging and near-term climate risks are established. Expert elicitation is a useful tool to facilitate responsive quantification and tracking of near-term climate risk; and the Delphi method enables climate scientists and sector risk experts to express concerns in respect of risk pathways that are currently difficult to forecast within climate impact models.

162 Based on multiple conversations and workshop feedback.
163 Ibid.

About the authors

Dr Daniel Quiggin is a senior research fellow with the Environment and Society Programme at Chatham House. He has expertise in the modelling, analysis and forecasting of national and global energy systems, having modelled various UK and global energy scenarios.

As a senior policy adviser at the UK Department for Business, Energy & Industrial Strategy in 2018–20, Daniel led work on the post-Brexit policy implications for the energy sector's trade of goods and services, and helped shape effective strategies for the energy and climate package of the UK–EU FTA negotiations. He also previously worked as an analyst at Investec Asset Management within a commodities and resources investment team.

Daniel holds master's degrees in particle physics and climate science, and a PhD in energy system modelling.

Ruth Townend is a research fellow with the Environment and Society Programme at Chatham House. Prior to joining Chatham House, she spent 12 years researching sustainability and climate change including as part of the Energy and Environment team at Ipsos MORI.

Ruth has led on a wide variety of high-profile quantitative and qualitative sustainability research projects for government clients, charities, trusts and foundations. This work has included: establishing the first robust, UK-wide tracker of net zero relevant public behaviours on behalf of the UK Department for Business, Energy & Industrial Strategy; exploring global public attitudes to planetary boundaries for the Global Commons Alliance; and groundbreaking research into global public understanding of the links between meat consumption and climate change, on behalf of Chatham House. Ruth holds a degree in social anthropology from the University of Cambridge.

Professor Tim G. Benton leads the Environment and Society Programme at Chatham House. He joined Chatham House in 2016 as a distinguished visiting fellow, at which time he was also Dean of Strategic Research Initiatives at the University of Leeds. From 2011 to 2016, he was the 'champion' of the UK's multi-agency Global Food Security programme.

Tim has worked with UK governments, the EU and the G20. He has been a global agenda steward of the World Economic Forum, and is a co-author of the Intergovernmental Panel on Climate Change's *Special Report on Food, Climate Change and Land* (2019) and of the UK's *Climate Change Risk Assessment* (2017, 2022).

Tim has published more than 150 academic papers, many of these tackling how systems respond to environmental change. His work on sustainability leadership has been recognized with an honorary fellowship of the UK's Society for the Environment, and an honorary doctorate from the Université catholique de Louvain, Belgium.

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Cover image: People rest at the Oregon Convention Center cooling station in Portland, Oregon, on 28 June 2021, as a heatwave moves over much of the US.
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CHATHAM HOUSE

The Royal Institute of International Affairs
Chatham House
10 St James's Square, London SW1Y 4LE
T +44 (0)20 7957 5700
contact@chathamhouse.org | chathamhouse.org

Charity Registration Number: 208223