AUSTRALIAN SECURITY LEADERS CLIMATE GROUP

Submission to the Inquiry into

FOOD SECURITY IN AUSTRALIA

by the House of Representatives Standing Committee on Agriculture

aslcg.org

Contents

Submission to HoR Standing Committee on Agriculture Inquiry into Food Security in Australia.

Published 8 December 2022
by Australian Security Leaders Climate Group, Canberra ACT.
Executive Committee: Admiral Chris Barrie AC (Retd), Air Vice-Marshal John Blackburn AO (Retd), Colonel Neil Greet (Retd), Cheryl Durrant, Major Michael Thomas (Retd) & Ian Dunlop.

www.aslcg.org

1. Overview and recommendations

The Australian Security Leaders Climate Group (ASLCG) welcomes the opportunity to contribute to the Standing Committee on Agriculture's Inquiry into Food Security in Australia.

This submission addresses the fourth point in the Inquiry's Terms of Reference, namely: "The potential opportunities and threats of climate change on food production in Australia".

In June 2022, ASLCG published the report, *Food Fight: Climate change, food crises & regional insecurity*, which is appended to this submission.[1]

Food Fight described some of the consequences of a hotter world for water and food insecurity globally and in Australia, in a world where global demand for food by 2050 is likely to be 50% higher than today. Over that time, the impacts of climate change on the capacity to feed the global population, which is projected to increase 20% over three decades, will have a profound negative impact on human and global security.

In 2021, Chatham House, Britain's eminent international affairs think tank, warned that the world "is dangerously off track to meet the Paris Agreement goals", the risks are compounding, and "without immediate action the impacts will be devastating in the coming decades", especially for food security.[2] The think tank's report, *Climate Change Risk Assessment* 2021, concluded that:

- Impacts likely to be locked in for the period 2040–50 unless emissions rapidly decline include a global average 30% drop in crop yields by 2050;
- The average proportion of global cropland affected by severe drought will likely rise to 32% a year (where severe drought is defined as greater than 50% yield reductions);
- By 2040, almost 700 million people a year are likely to be exposed to droughts of at least six months' duration, nearly double the global historic annual average; and
- Cascading climate impacts will "drive political instability and greater national insecurity, fuelling regional and international conflict".

Such a cascading climate–security crisis initiated by chronic water shortages, crop failures and diminishing yields is likely to emerge globally, including across vulnerable nations and regions in the Asia–Pacific.

There will be big consequences for Australia's economic and human security, both because Australia's own food growing systems will be disrupted, and because food insecurity in the region will drive political instability, conflict, and people displacement.

The Chatham House report clearly demonstrates that it is not appropriate to conduct separate analyses in silos for distinct "domestic" and "global" food-security risk because key interactions and cascades between the particular and the general would be overlooked.

Recommendations

ASLCG commends the summary and recommendations of *Food Fight* to the Inquiry as follows:

- Australia is ill-prepared for the security implications of climate-change enhanced global food crises and their systemic, cascading risks to human and global security;
- Australia's capacity to assess the national and regional vulnerabilities, and understand the consequences, is inadequate;
- Understanding and assessing climate–security risks in general is an urgent, outstanding task for the Australian Government, as advocated in the ASLCG's *Missing in Action* report;

[1] https://www.aslcg.org/wp-content/uploads/2022/06/ASLCG-Food-Fight-Report-June-2022-1.pdf
[2] https://www.chathamhouse.org/2021/09/climate-change-risk-assessment-2021

- As part of that assessment, and in developing a National Resilience Strategy, an urgent review should be undertaken of Australia's food production and supply chain resilience in a hotter climate;
- To mitigate the risks, Australia should commit to strong emission reductions and, as a high per-capita emitter, aim to achieve zero emissions as close to 2030 as possible;
- To enhance the capacity of neighbours to withstand climate-changed driven food shocks and their security consequences, Australia should contribute to deploying a monitoring system to identify potential food insecurity hotspots, and commit to a programme to enhance food production capacity and resilience in the region.

In addition, ASLCG draws attention to the fundamental issue at the heart of the Inquiry's remit, namely how should the impacts of climate warming on Australia's food security be assessed and what is an appropriate methodology for assessing such risks, when they are clouded in large uncertainties, including devastating high-end possibilities? We recommend:

- An interdisciplinary, whole-of-government and whole-of-system analysis that integrates all risks to food security. (We recognise that this is obviously beyond the resource capacity of the present inquiry.)
- Emphasising to the government the need for ongoing, comprehensive climate–security (including food security) risk analysis that integrates the local and the global, national and human security considerations, avoiding siloed or partial analyses that will likely miss key threats.

2. The Chatham House report

In establishing a framework for assessing climate-related food security risks, we draw attention to the 2021 Chatham House report, *Climate Change Risk Assessment*, which in our view is the most substantial piece of work in this area yet published. It is a valuable guide, especially since it places food and water insecurity at the heart of its risk assessment.

The picture of the world in 2040–2050 that Chatham House describes is relevant to the inquiry because the impacts on global food security have a profound effect on Australia, both as a major food exporter and because the globalisation of food markets means that the steep global increases in food prices that will occur in the Chatham House scenario will be reflected in steep price rises in Australia too. This in itself will be a major contributor to food insecurity in a hotter Australia, as just one example of the impacts.

The Chatham House scenario, in which emission reductions are insufficient to achieve the Paris climate goals, and warming reaches 2°C around mid-century, draws the following picture:

CROPS

- To meet global demand, agriculture will need to produce almost 50% more food by 2050. However, yields could decline by 30% in the absence of dramatic emissions reductions.
- Between 1980 and 2019, global average crop yield potentials for maize, winter wheat, soybeans and rice have declined, with reductions of 5.6%, 2.1%, 4.8% and 1.8%, respectively.
- By the 2040s, the probability of a 10% yield loss, or greater, within the top four maize producing countries (the US, China, Brazil and Argentina) rises to between 40 and 70%. These countries currently account for 87% of the world's maize exports. The probability of a synchronous, greater than 10% crop failure across all four countries during the 2040s is just less than 50%.
- Globally, on average, wheat and rice together account for 37% of people's calorific intake.
    - The central 2050 estimate indicates that more than 35% of the global cropland used to grow both these critical crops could be subject to damaging hot spells. But this vulnerability could exceed 40% in a plausible worst-case scenario.
    - By 2050, South Asia is likely to be the most impacted, with more than 60% of winter wheat, spring wheat and rice exposed to damaging hot spells.
    - The central estimate for 2050 also indicates these same global cropland areas will be impacted by reductions in crop duration periods of at least 10 days, exceeding 60% for winter wheat, 40% for spring wheat, and 30% for rice.
    - Nearly 75% of European winter wheat is subject to equally yield-reducing conditions (reductions in crop duration periods), up from almost 6% historically.
- Under the central estimate, more than 40% of African maize growing areas are likely to be subject to reductions in crop duration periods of at least 10 days by 2050, up from 0.3% historically. Maize, winter wheat and spring wheat make up around 38% of Asian croplands. In aggregate, 40% of the growing area is likely to be subject to reductions in crop duration periods of at least 10 days by 2050, with winter wheat the most impacted (over 50%) under the central estimate.
- Crop yields are likely to be reduced by the conditions represented by the three impact indicators of agricultural drought, shorter crop durations and heat stress. The dramatic increase in frequency and probability of these extreme events in all regions even under the central estimate – let alone under the plausible worst-case scenario – indicates that yields could be dramatically reduced.

DROUGHT

- The global food crisis of 2007–08, caused by depleted grain stores, Australian drought and regional crop failures, led to a doubling of global food prices, export bans, food insecurity for importers, social

unrest, and mass protests in countries including Cameroon, Egypt, Indonesia, Mexico, Morocco, Nepal, Peru, Senegal and Yemen.

- By 2040, the average proportion of global cropland affected by severe drought (>50% yield reductions) will likely rise to 32% a year, more than three times the historic average. By 2050 this increases to almost 40%.
    - Europe has the second largest cropland area (20% of global total), and is likely to experience the largest increase in area affected by agricultural drought, with the central estimate indicating that nearly half the cropland area will experience severe periods of drought by 2050. Africa 44% and North Africa 38%.
- Assuming global cropland remains constant at 14.7 million square kilometres, by 2050 the central estimate indicates that nearly 40% of that area will be exposed to severe drought for three months or more each year; however, this could reach just over 50% under the plausible worst-case scenario.[3]
- By 2040, almost 700 million people a year are likely to be exposed to droughts of at least six months' duration, nearly double the global historic annual average. By 2040, North Africa, the Middle East, Western and Central Europe, and Central America will all see more than 10% of their populations impacted by prolonged severe drought. No region will be spared, but by 2040 East and South Asia will be most impacted – with, respectively, 125 million and 105 million people likely to experience prolonged drought. Across Africa, 152 million people each year are likely to be impacted.
- Farmers in the worst-affected areas (including the critical breadbasket regions of southern Russia and the US) are likely to experience severe agricultural drought impacting 40% or more of their cropland area every year during the 2050s.

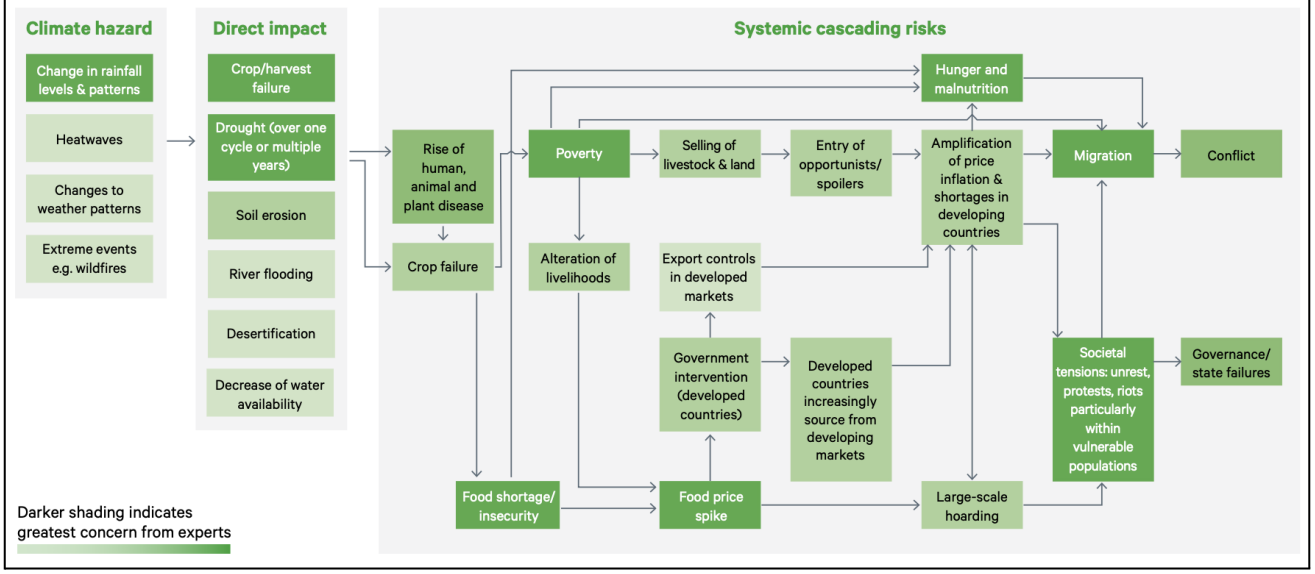
WATER SECURITY

- Over twice the global land area was affected by drought in 2019, compared with the historic baseline. In the Sahel in 2020, some 13.4 million people in Mali, Niger and Burkina Faso were reported as being in need of humanitarian assistance because of drought.
- Setting Asia aside, the continent with the greatest number of people likely to be impacted by hydrological drought is Africa, exceeding 180 million by 2050 under the central estimate. Africa is also likely to suffer the greatest increase of people experiencing drought relative to the historic baseline (1981–2010), by 290% from just below 63 million.
- North Africa and the Middle East are likely to have the greatest proportion of their populations experiencing severe water stress (i.e. availability of less than 500 cubic metres per head per year), at 17% and 14%, respectively, in 2050. As Figure 16 illustrates, many regions of the world are likely to see 40% or greater increases in the difference between supply and demand of water by 2040, relative to the historic baseline.

This analysis became one of the inputs into Chatham House's global assessment of the overall systemic climate–security risks. This broader assessment of second-order impacts was done by expert elicitation based on an iterative process, and provides a good model for a comprehensive Australian climate–food–security risk assessment. The Chatham House results relating to food insecurity are illustrated as follows:

[3] A severe drought is a period of at least three months with a SPEI-6 less than -1.5. SPEI: Standardised Precipitation-Evapotranspiration Index (SPEI: Vicente-Serrano et al., 2010).

Figure 23. Experts' assessments of systemic cascading climate risks that are likely to lead to food insecurity



Experts' assessments of systemic cascading climate risks that are likely to lead to food insecurity
(Source: Quiggin, D et al. 2021, *Climate change risk assessment 2021*, Chatham House, London)

In this analysis, impacts of greatest concern are crop/harvest failure, resulting in food price spikes, food shortages/insecurity and poverty, which in turn become drivers for migration and societal tensions (unrest, protests, and riots particularly within vulnerable populations).

In engaging with the Chatham House analysis, there is sobering clarification provided: "If tipping points are reached at lower temperatures, the impacts presented in the previous sections are likely to be *an underestimate, occurring with a higher probability, sooner in time*. Moreover, the severity and frequency of the impacts will be far more extreme, which in turn will hugely reduce the capacity of societies the world over to adapt, compounding the impacts. Global temperatures can rise significantly beyond those characterized in the previous sections" (emphasis added).[4]

In other words, the Chatham House analysis may underestimate the plausible worst-case possibilities.

[4] https://www.chathamhouse.org/2021/09/climate-change-risk-assessment-2021

3. Methodology for Australian domestic climate-food-security risk assessment

In our *Missing in Action* report last year, the Australian Security Leaders Security Group advocated to all political parties the need for an urgent and comprehensive climate–security risk assessment,[5] because this had never been done for Australia, and is an essential first step in designing realistic climate policy.

Labor incorporated this idea into their election platform, *Powering Australia*, and the Albanese government subsequently requested ONI to carry out an interim assessment,[6] albeit this is focused on global but not domestic risks. Thus a comprehensive climate risk assessment which includes a domestic focus remains an outstanding, urgent, task for the Australian Government.

ASLCG's report, *Australian Climate & Security Risk Assessment: Implementation Proposal* published in June 2022,[7] suggested how the government's commitment to such an assessment might proceed. The recommendations remain relevant to the task still at hand. In addition to the initial risk assessment itself, the report proposed two further initiatives:

1. **Triennial climate science assessments, which should be an output of a revamped Climate Change Authority.**
    - Based on the model used in the USA, triennial reports to Parliament coordinated by the Climate Change Authority, prepared by a high-level expert group working with relevant agencies including BoM, CSIRO and university researchers, to provide a regular, publicly-available assessment of climate trends, risks and impacts; including reporting between full assessments as required.
    - A valuable tool for policy-making, in providing both national and regional projections, impacts and scenarios, and hence mitigation and adaptation frameworks.
    - Provides a rigorous risk-management framework for government policy-making and planning across a wide range of portfolios, including transport, health, infrastructure, energy, environment, emergency services, and defence.
    - Provides an opportunity for public education and engagement on the issues.
2. **Full-spectrum climate security intelligence capacity.**
    - The government should adopt a "full spectrum" strategic approach by building an Australian climate risk "early warning system" capacity to identify and respond to current or emerging direct climate risks to national interests.
        - The role is to provide ongoing support to key stakeholders across the policy and innovation spheres, noting that:
        - Australia's national interest is threatened by severe, but increasingly plausible, climate change scenarios.
        - Risks are real and physical, requiring adaptation with appropriate warnings.
        - Risks are real and financial, requiring corporate, business, government and NGO behavioural change.
        - Acknowledge that risk mitigation is a whole-of-society undertaking.

[5] www.aslcg.org/wp-content/uploads/2021/09/ASLCG_MIA_Report.pdf
[6] www.theguardian.com/environment/2022/jun/22/anthony-albanese-to-order-intelligence-chief-to-examine-security-threats-posed-by-climate-crisis
[7] www.aslcg.org/wp-content/uploads/2022/08/ASLCG_RiskAssessment_Implementation-Proposal.pdf

- The approach should maximise collective intelligence capacity, and break down thematic and organisational silos, to give longer-term perspectives, and provide regular assessments by consistent monitoring and assessment of climate-security risks.
- Structure: Led by the Department of Prime Minister and Cabinet, with interdepartmental working groups, and external contracted expertise as required.

Food security would be a key component of these iterative processes.

Key issues and framing in assessing food insecurity risks

In understanding food–security risks for Australia, three questions loom large: how hot are we expecting our climate to become, what is the nature of the risks that we need to understand, and what is the scientific knowledge base we need? We offer the following responses to these questions.

The latest International Energy Agency projections show that global carbon emissions from energy may peak in 2025, but are likely to plateau at a high level after that, rather than decline in any significant manner.[8] As atmospheric levels of all three main greenhouse gases reach record highs,[9] what does this mean for future warming and the Paris Agreement commitments?

The warming trend will reach 1.5°C around 2030, irrespective of any emission reduction initiatives taken in the meantime;[10] the UN Environment Program says there is no longer a credible path to holding warming below 1.5°C in the short term,[11] without deploying global cooling interventions. Keeping warming to 2°C means aiming for zero emissions by 2030 for high-per capita emitters such as Australia, but emissions and greenhouse gas levels are still rising, and the 2°C target will very likely be missed by a significant margin,[12] as the Chatham House analysis suggests.

When large-scale, self-reinforcing climate system feedbacks are considered, current emission-reduction commitments are estimated to lead to around 3°C of warming, which US security analysts say may result in a world of "outright chaos".[13] And six in ten climate scientists surveyed by *Nature* journal say that they expect the world to warm by at least 3°C by the end of the century.[14]

So when Australia does assess the future domestic threats that climate warming poses, it must look in detail at what a 3°C (and more) hotter world would mean for our nation, because we are now in an era of existential climate risks. The recently-released United States 2022 *National Security Strategy* recognises that: "Of all of the shared problems we face, climate change is the greatest and potentially [most] existential for all nations."[15]

So how will 3°C risks manifest from a security perspective? A remarkable insight was provided fifteen years ago by Kurt Campbell, currently Coordinator for Indo-Pacific Affairs in the US

[8] https://www.theguardian.com/environment/2022/oct/27/carbon-emissions-to-peak-in-2025-in-historic-turning-point-says-iea
[9] https://www.theguardian.com/environment/2022/oct/26/atmospheric-levels-greenhouse-gases-record-high
[10] www.science.org/doi/10.1126/science.abo3378; https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf, table SPM.1; www.economist.com/interactive/briefing/2022/11/05/the-world-is-going-to-miss-the-totemic-1-5c-climate-target; The 2022 NSW *Climate Change Adaptation Strategy* states: "According to the IPCC Sixth Assessment Report, even under the lowest greenhouse gas emissions scenario, global surface temperature is expected to rise by up to 1.7°C within the next 20 years and could reach 2°C within 40 years compared to pre-industrial levels (1850–1900). Under higher emissions scenarios, warming could reach as high as 1.9°C within 20 years (IPCC 2021a)" (www.climatechange.environment.nsw.gov.au/nsw-climate-change-adaptation-strategy).
[11] https://www.unep.org/resources/emissions-gap-report-2022
[12] unfccc.int/sites/default/files/resource/cma2022_04.pdf;
www.theguardian.com/environment/2022/oct/26/atmospheric-levels-greenhouse-gases-record-high
[13] www.csis.org/analysis/age-consequences
[14] www.nature.com/articles/d41586-021-02990-w
[15] www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf

National Security Council, and formerly Assistant Secretary of State for East Asian and Pacific Affairs in the Obama administration. Campbell led a team that produced climate scenarios in a 2007 report, *The Age of Consequences*.[16] One scenario described the security impacts in a 3°C-warmer world, which is now on the cards:

> Massive nonlinear events in the global environment give rise to massive nonlinear societal events. In this scenario, nations around the world will be overwhelmed by the scale of change and pernicious challenges, such as pandemic disease. The internal cohesion of nations will be under great stress, including in the United States, both as a result of a dramatic rise in migration and changes in agricultural patterns and water availability. The flooding of coastal communities around the world, especially in the Netherlands, the United States, South Asia, and China, has the potential to challenge regional and even national identities. Armed conflict between nations over resources, such as the Nile and its tributaries, is likely and nuclear war is possible. The social consequences range from increased religious fervor to outright chaos. In this scenario, climate change provokes a permanent shift in the relationship of humankind to nature.

And a 2017 survey of global catastrophic risks by the Global Challenges Foundation (GCF) found that: “In high-end [climate] scenarios, the scale of destruction is beyond our capacity to model, with a high likelihood of human civilisation coming to an end.”[17] The GCF says that despite scientific evidence that risks associated with climate tipping points “increase disproportionately as temperature increases from 1°C to 2°C, and become high above 3°C”, political negotiations have consistently disregarded the high-end scenarios that could lead to abrupt or irreversible climate change. It concludes that “the world is currently completely unprepared to envisage, and even less deal with, the consequences of catastrophic climate change”.[18]

Existential, civilisation-threatening risks are not amenable to the learn-from-failure approach of conventional risk management, and require a focus on the most-damaging possibilities, not just the middle-of-the-road or most likely outcomes. Responsible existential risk management means that attention should be given to the question: “What are the feasible, worse-case scenarios, and what actions are required to prevent, prepare and protect against their occurrence?”

Chatham House offers a plausible worst-case scenario, which is warming of 3.5°C or more.[19]

The Earth’s climate is currently undergoing abrupt change and exhibiting amplifying feedbacks and non-linear changes that are happening faster than forecast only two decades ago.[20] Johan Rockstrom, director of the Potsdam Institute, acknowledges that: “Without doubt, extreme weather events, amplified by global warming, are coming faster than predicted and are more severe than predicted”.[21]

In Australia, the unprecedented Black Summer fires were beyond the worst expectations, rapid rain bursts in Sydney have become at least 40% more intense in just two decades,[22] one-in-a-100-year floods are repeatedly occurring, and we are twenty years behind in considering

[16] www.csis.org/analysis/age-consequences
[17] globalchallenges.org/wp-content/uploads/2019/07/Global-Catastrophic-Risks-2017.pdf
[18] globalchallenges.org/wp-content/uploads/2019/07/Global-Catastrophic-Risks-2017.pdf
[19] The Chatham House assessment is based on the RCP4.5 scenario as being most closely aligned with the projected emissions scenario. RCP4.5 has an uncertainty range of 10% under 2°C, 25% of 3°C+ and 10% of >3.5°C, with a mean 2.7°C. It then identifies a plausible worst-case scenario as being the upper end of an estimated distribution of potential impacts (the 90th percentile) of RCP4.5, that is 3.5°C or more.
[20] theconversation.com/we-climate-scientists-wont-know-exactly-how-the-crisis-will-unfold-until-its-too-late-133400
[21] www.theguardian.com/environment/2022/oct/30/cop27-climate-summit-window-for-avoiding-catastrophe-is-closing-fast
[22] theconversation.com/think-storms-are-getting-worse-rapid-rain-bursts-in-sydney-have-become-at-least-40-more-intense-in-2-decades-194159

current and future rainfall extremes.[23] In Canberra, the number of extreme heat days (>40°C) over the last decade was higher than projections for the 2030s.[24]

Limitations in current scientific knowledge lead to uncertainty about the magnitude of future extreme climate events, and hence the scale of future climate-related emergencies. This is a big challenge when conducting a domestic risk assessment. Extreme impacts will intensify with future warming, and climatic tipping points potentially create further large uncertainties, both becoming a source of sudden, unanticipated risks.

There has been an underestimation of the scale and scope of climate-related security risks — human, regional and global — many of which remain poorly understood due to the complexity of cascading consequences. But the harsh reality is that without an emergency level of mobilisation, we may be heading towards societal collapse. The 2022 UN report *Our World at Risk: Transforming Governance for a Resilient Future*, warns of the risk of collapse because "risk creation is outstripping risk reduction". That is, disasters, economic loss and the underlying vulnerabilities that drive risk, such as poverty and inequality, are increasing just as ecosystems and biospheres are at risk of collapse. Global systems including food are becoming more connected and more vulnerable in an uncertain risk landscape.[25]

To understand the level of security threat and how to respond, Australia needs a sound base of knowledge about the projected physical impacts and the tools to analyse their social and economic consequences. This requires expertise that is well managed and organised, and available in a transparent manner. But due to past political neglect and malfeasance, there is an institutional expertise deficit in Australia at present.

Over the years the management of BoM and CSIRO have downplayed climate risks, underestimated the worst-case scenarios, failed to communicate the high-end possibilities and defunded critical work. National funding for adaptation analysis and planning has been strangled. Private sector analysis is generally timid and too dependent on conservative scientific projections, though some work by the insurance sector and some banks is of a higher quality. State government analysis on sea-level rise risks, for example, is largely based on out-of-date projections compared, say, to US government agencies or Pentagon scenarios.

Valuable knowledge was gathered for the Academy of Sciences' 2021 report on *The risks to Australia of a 3°C warmer world*,[26] and there is a lot of expertise in the multi-university climate research networks.

But the bottom line is that expertise will have to be re-harnessed and resourced appropriately if a risk assessment is to be soundly based so that Australia has the capacity to respond effectively to life on a hotter continent.

A final note

The Chatham House analysis makes it clear that it is not possible to understand climate-related food insecurity risks in isolation, that is, by starting with projected changes in the physical system and in a linear way translate them to changes in water availability, drought frequency and severity, crop yields and so on, to draw a conclusion. Many second- and third-order effects come into play. For

[23] www.abc.net.au/news/2022-11-19/climate-change-rainfall-extremes-probable-maximum-flood/101672120
[24] Fin publication
[25] www.undrr.org/gar2022-our-world-risk
[26] www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/risks-australia-three-degrees-c-warmer-world

example, climate warming will contribute to conflict, wars and forced displacement, as it has in Syria and across the Sahel. We are currently experiencing the global impacts on supply chains, the energy system, food prices and availability of the war in Ukraine. In a hotter world such disruptions will become more frequent as impacts and consequences cascade around a complex global system. There is no simple, linear, cause-and-effect analysis for food insecurity. It can only be revealed as part of a broader understanding of whole-system complexity.

Nor is it appropriate to conduct separate analysis in silos for distinct “domestic” and “global” food-security risk because key interactions and cascades between the particular and the general may be overlooked.

Hence the need for an on-going interdisciplinary, whole-of-government and whole-of-system climate–security (including food security) risk analysis that integrates the global and the local, national and human security considerations, and avoids siloed or partial analyses that will likely miss key threats.

AUSTRALIAN
SECURITY
LEADERS
CLIMATE
GROUP

FOOD FIGHT

Climate change, food crises & regional insecurity

ISSUE REPORT | 2022

CONTENTS

FOOD FIGHT: CLIMATE CHANGE, FOOD CRISES & REGIONAL INSECURITY
Published June 2022 by Australian Security Leaders Climate Group
PO Box 3107, Manuka, ACT, 2603 E: info@aslcg.org

Cover Photo: Displaced Iraqis gather to get food distribution at a refugee camp in Qayyarah south of Mosul, on 2016. (BULENT KILIC/AFP via Getty Images).

SUMMARY & RECOMMENDATIONS

- Australia is ill-prepared for the security implications of climate-change enhanced global food crises and their systemic, cascading risks to human and global security.
- Australia's capacity to assess the national and regional vulnerabilities, and understand the consequences, is inadequate.
- Understanding and assessing climate-security risks in general is an urgent task for the Australian Government, as advocated in the ASLCG's *Missing in Action* report, and to which Labor committed in its *Powering Australia* policy.
- As part of that assessment, and in developing a National Resilience Strategy, an urgent review should be undertaken of Australia's food production and supply chain resilience in a hotter climate.
- To mitigate the risks, Australia should commit to strong emission reductions and, as a high per-capita emitter, aim to achieve zero emissions as close to 2030 as possible.
- To enhance the capacity of neighbours to withstand climate-changed driven food shocks and their security consequences, Australia should contribute to deploying a monitoring system to identify potential food insecurity hotspots, and commit to a programme to enhance food production capacity and resilience in the region.

"FOOD & WATER INSECURITY ARE MAJOR DRIVERS OF CASCADING CLIMATE IMPACTS, AND CONTRIBUTE TO DETERIORATING SECURITY ENVIRONMENTS ACROSS THE WORLD AND IN STRATEGICALLY SIGNIFICANT AREAS FOR AUSTRALIA SUCH AS THE ASIA- PACIFIC."

CLIMATE RISK ASSESSMENT 2021, CHATHAM HOUSE

Photo: Maharashtra, India -Residents climb on municipal water tanker to fill their containers during water storages 2016.

INTRODUCTION

Global demand for food by 2050 is likely to be 50% higher than today. Over that time, the impacts of climate change on the capacity to feed the global population — projected to increase 20% over three decades — will have a profound negative impact on human and global security.

In 2021, Chatham House, Britain's eminent international affairs think tank, warned that the world "is dangerously off track to meet the Paris Agreement goals", the risks are compounding, and "without immediate action the impacts will be devastating in the coming decades", especially for food security.[1] The think tank's report, *Climate change risk assessment 2021*, concluded that:

- Impacts likely to be locked in for the period 2040–2050 unless emissions rapidly decline include a global average 30% drop in crop yields by 2050;
- The average proportion of global cropland affected by severe drought will likely rise to 32% a year (where severe drought is defined as greater than 50% yield reductions);
- By 2040, almost 700 million people a year are likely to be exposed to droughts of at least six months' duration, nearly double the global historic annual average.
- Cascading climate impacts will "drive political instability and greater national insecurity, fuelling regional and international conflict".

Such a cascading climate-security crisis initiated by chronic water shortages, crop failures and diminishing yields, and amplified by more extreme climate events and supply-chain dislocations, is likely to emerge globally, including across vulnerable nations and regions in the Asia-Pacific.

There will be big consequences for Australia's economic and human security, both because Australia's own food growing systems will be disrupted, and because food insecurity in the region will drive political instability, conflict, and people displacement in ways that will significantly impact on Australia and the security of its people.

Yet Australia is ill-prepared for these events: in assessing their likelihood, understanding the consequences, acting now to reduce the risks, both by strong emission reduction and other actions, along with adaptation and development plans to assist its neighbours.

Understanding and assessing climate-security risks is an urgent task for the Australian Government and one the Labor government has committed to undertake. It should start with a comprehensive whole-of-nation **Climate and Security Risk Assessment** and the establishment of an Office of Climate Threat Intelligence as the foundation for a "**Prevent. Prepare. Protect." Climate-Security Action Plan** (see page 6).

THE CLIMATE–FOOD–SECURITY NEXUS

The impact of climate change on the health and wellbeing of peoples and nations starts with one element above all others: water and the ability to grow food.

In 2010, an extreme heatwave, lack of rain and unprecedented wildfires devastated more than a third of cultivable land in Russia, the world's fourth largest grain exporter, and reduced wheat production by 30%. In response, the Russian government banned wheat exports for several months. At the same time, severe droughts in China and the Ukraine contributed to a global wheat shortage and a doubling of the global price in late 2010. In those countries most dependent on wheat exports — which are in the Middle East and North Africa — the tripling of the spot price triggered food riots, becoming one trigger for the Arab Spring uprisings in late 2010.

The Middle East, North Africa and Mediterranean regions have experienced a drying trend over the last few decades. Sixty percent (60%) of Syria saw the worst long-term drought in millenia from 2007-11, and severe crop failures. By 2009, more than 800,000 Syrians in rural areas had lost their livelihood, and 2-3 million people had been driven into extreme poverty. Approximately 1.5 million people migrated to the cities which, on top of another 1.5 million refugees who had fled from the war in Iraq, forced up rents dramatically and created social unrest. The food and economic crisis, and government reductions in subsidies for basic goods, compounded other underlying issues for the Syrian people, who erupted in protest in early 2011, inspired by the Arab Spring. What followed was social breakdown, state failure, civil war and the rise of Islamic State. After ten years, Syria remains the world's largest refugee crisis. More than half the population has been displaced: more than 6.6 million Syrians have been forced to flee their country since 2011 and another 6.7 million people remain internally displaced.

Drought is leading to instability and water weaponization in the Middle East and North Africa. The wider consequences of the Syrian war included regional destabilisation, and mass migration which has contributed to social upheaval and the rise of populist movements or governments in parts of Europe.

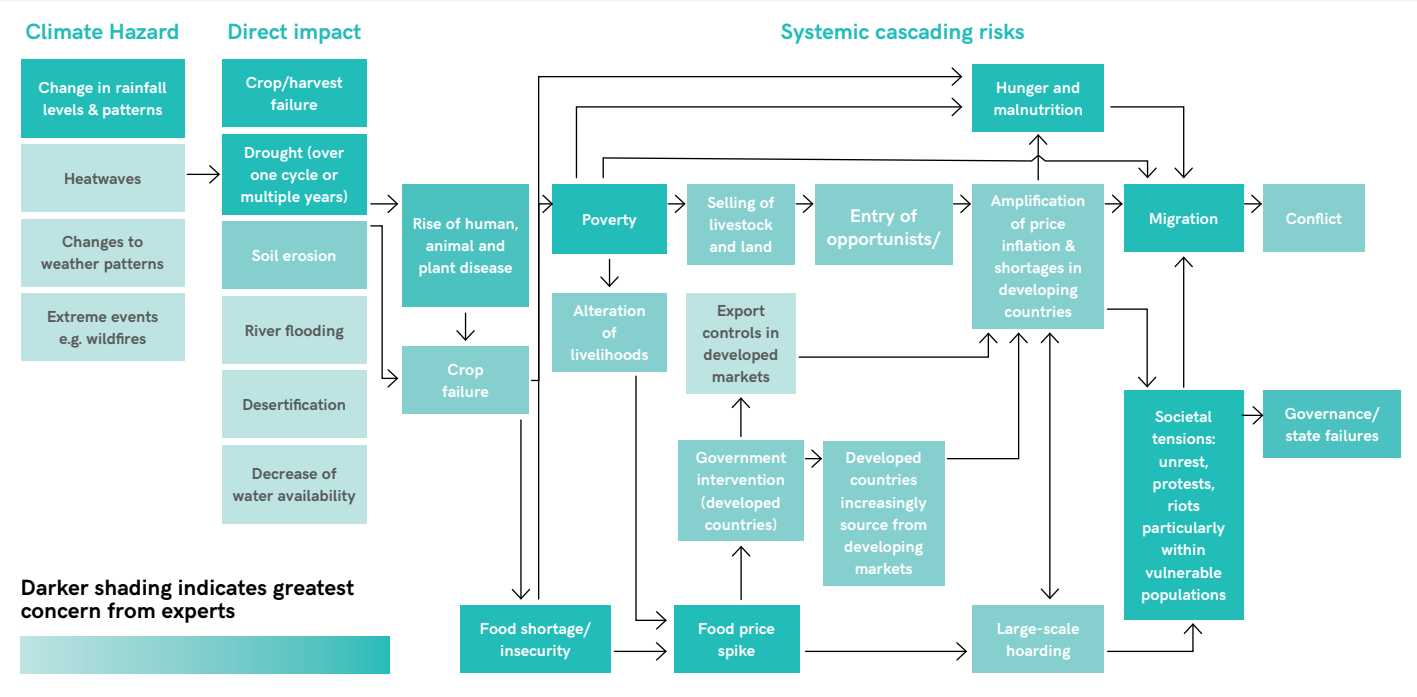
The Arab Spring, the Syrian war and Europe's refugee dilemmas are prime examples of how interactions between intersecting crises become accelerants to instability in unexpected ways. There are climate-change components to the conflicts in many countries across the Maghreb and the Middle East, not least the role of desertification in fueling war and displacement across the Sahel.[2]

These events vividly illustrate the climate–food–security nexus. Climate change, drought and desertification can worsen water insecurity and trigger food crises, resulting in humanitarian disasters, instability and civil unrest, forced migration and internal displacement, and war within and across borders. This leads to increasing burdens on military forces, whether in providing disaster relief and humanitarian assistance, or by necessitating a military or peacekeeping response to conflict.

A report for the UK Ministry of Defence published in November 2019, *A changing climate: Exploring the implications of climate change for UK Defence and Security*, uses a scenario with a 3.5°C temperature rise by 2100 to forecast climate change implications for the military. It says that as early as 2030, the world would face a perfect storm of food, water and energy crises: "The demand for food and energy is estimated to rise by 50% by 2030, while water demand has been projected to increase by 30%" so that "in regions where food shortages are combined with poor governance, climate change could contribute to civilian protests, rioting and an increased likelihood of violent conflict".[3]

This is consistent with assessments by expert panels, brought together by Chatham House, on the causes of systemic, cascading climate risk: "food and water insecurity are major drivers of cascading climate impacts, and contribute to deteriorating security environments across the world and in strategically significant areas for Australia such as the Asia-Pacific".[4]

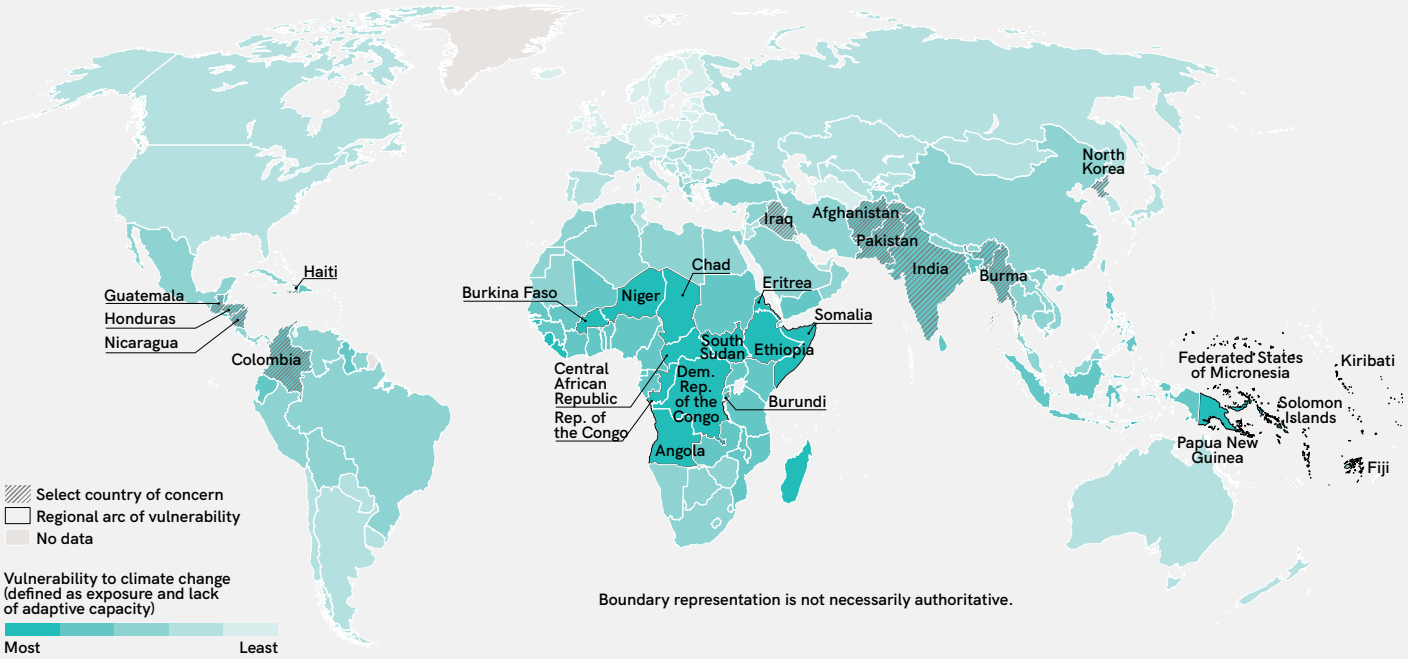
Experts' assessments of systemic cascading climate risks that are likely to lead to food insecurity



(Source: Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London)

Climate change in select highly vulnerable countries of concern

Highly climate-vulnerable countries of concern according to US intelligence: "Diminished energy, food, and water security in the 11 countries probably will exacerbate poverty, tribal or ethnic intercommunal tensions, and dissatisfaction with governments, increasing the risk of social, economic, and political instability."



(Source: NIC 2021, Climate change and international responses increasing challenges to US national security through 2040, National Intelligence Council, NIC-NIE-2021-10030-A)

PREVENT. PREPARE. PROTECT.

Summary: A Climate–Security Risk Action Plan for Australia

Demonstrate leadership

- **Acknowledge** climate disruption is an existential risk to society, a threat to the stability of nations, and the relationships between them if we act too late, or inadequately.
- **Seize** the initiative by conducting informed, national public conversations and working with all levels of government, communities, business and academia in carrying out regular National Climate Risk Assessments.
- **Show** the Australian people that our leaders care by committing to protecting the Australian people with actionable and credible climate plans to safeguard our future.

Assess climate risks

- **Appoint** an independent, expert panel to urgently conduct a comprehensive Climate and Security Risk Assessment, using the best available information.
- **Establish** an Office of Climate Threat Intelligence.
- **Assess** the threats and impacts of climate disruption with brutal honesty, identifying the worst, as well as most likely, cases and considering the full range of possibilities.

Coordinate and cooperate

- **Coordinate** a holistic, whole-of-government approach, building capacity across the public service and government agencies, and at all levels of government.
- **Cooperate** with big and small Asia-Pacific governments to build alliances for climate action, understanding that cooperation rather than conflict is key to responding to the climate crisis.
- **Build** an Australian National Prevention and Resilience Framework with coherent processes across critical areas including energy and water, logistics, health, industry and agriculture, research and environment.

Act and invest with urgency

- **Prevent** devastating climate impacts by mobilising all the resources necessary to reach zero emissions as fast as possible. Cooperate to develop the global capacity to prevent irreversible tipping points and drawdown greenhouse gases back to safer conditions in the long term.
- **Prepare** to manage the risks and respond to the challenges of living in a climate-change-disrupted world with a responsibility to prepare and prevent.
- **Protect** the most vulnerable communities, nations and ecological systems.

WAR IN UKRAINE & GLOBAL FOOD INSECURITY

The war in Ukraine is one domino in a network of events, including climate change, impacting food supply and price, and peoples' capacity to survive in increasingly fragile natural and social environments.

The 2022 exceptional and extended 50-degree heat wave in South Asia jeopardized India's wheat supply as crops died in the dry heat, with estimates that yields will slump 15-50% this season in the world's second-largest wheat-growing nation. As a result India has banned wheat exports.

Grain shortfalls drive up prices, and higher food and energy prices are drivers of social instability and conflict. This was the case in the Arab Spring, which followed a tripling of the spot price for wheat after climate-related harvest failures in China, Russia, Ukraine and Australia. Additional pressures on food and energy supply created by war, coupled with an already vulnerable climate, significantly increase the risks to human security.

In the month after Russia's 24 February 2022 invasion of Ukraine, world wheat prices increased by around 21%, barley by 33%, and some fertilizers by as much as 40%.[5]

Food related protests have occurred in the Middle East since Russia's invasion, but even before then, the UN food price index was already higher in real terms than at the height of the global hunger crisis a decade ago and the Arab Spring. The World Food Programme (WFP) warned of "catastrophic" scarcity for several hundred million people in November 2021. Food and agricultural experts warned of increasing food insecurity in poorer countries, many of which were already suffering from high hunger levels because of the coronavirus pandemic.[6]

The impact of the war in Ukraine on food and human security will depend on the conflict's duration and intensity. Wheat exports from Ukraine have been stopped by a Russian blockade. In March 2022, Ukraine had stocks of around 20 million tonnes of wheat and corn still to export from the 2021-22 season but was unable to do so. There is an open question as to the extent to which Ukrainian farmers will be able to plant this year's crops. At the same time, China is reporting that its current wheat harvest may be the worst in recent decades.

This combination — concurrent wheat supply crises in Ukraine, Russia, India and China — may again drive social unrest and conflict if the supply constraints and higher prices are maintained for a longer period.

Russia and Ukraine combined produce 12% of total food calories traded in the world. And between them, Russia and Ukraine export around one-quarter of all traded wheat, more than three-quarters of traded sunflower oil, and one-sixth of traded maize."[7]

The consequences are being felt in many places, including in the Horn of Africa, where climate change and declining average rainfall over four decades have been a contributing factor to social instability, state breakdown and conflict. Food insecurity in the arid and semi-arid parts of the region is growing. The WFP says outright famine is likely in Somalia, where 40% of people face acute food insecurity as well as widespread jihadi violence. The conflict in Tigray has left nine million people food insecure, and in Kenya drought has resulted in three million people becoming food insecure. In Ethiopia, three-quarters of the wheat distributed by the WFP and the government comes from Ukraine and Russia. With rising global wheat prices, there is not the capacity to obtain enough grain. Murithi Mutiga, Africa programme director at Crisis Group in Nairobi says that less predictable rainfall will become "a huge contributor to instability".

In May 2022, The UN Food and Agriculture Organisation identified 20 "hunger hotspot" countries facing a critical food emergency or already in catastrophe and "projected to experience starvation and death". Chatham House analysts say the Ukraine crisis could trigger cascading risks globally. And Abdolreza Abbassian, the FAO's former head of agro-markets, said that food prices could go higher yet and stay there: "The real danger is the 2022-2023 season, and it will bring down governments."[8]

DROUGHT & WATER STRESS IN A HOTTER WORLD

Drought and water stress, driven by climate change, will contribute to conflict and the deterioration in security environments across many parts of the world. This directly impacts Australia's ability to contribute toward a secure region and will stretch the resources of Australia's military and security apparatus.

The agricultural sector is currently responsible for around 70% of global freshwater consumption. Patterns of land use, population growth, rapid urbanisation, economic development and changing dietary patterns can be expected to have significant effects on demand, in some cases creating or exacerbating competition for supplies.[9]

Between 1970 and the mid-1990s, the amount of economically available water per person globally dropped by more than 35%, according to the United Nations.[10] In 2010, almost 2.4 billion people were living in watersheds with less than 1000 cubic metres per capita per year (defined as chronic water shortage); and approximately 800 million people were living in watersheds with less than 500 cubic metres per capita per year (extreme water shortage).[11]

As the world's population and living standards continue to grow, the projected climate impacts on the nexus of water, food, and energy security become more severe. By 2030, population growth and a burgeoning global middle class will result in a worldwide demand for 35% more food and 50% more energy, compared to 2014.[12] One estimate projects a 2030 gap of 40% between global water requirements and accessible, reliable water supply.[13]

By 2035, "more than 30 countries — nearly half of them in the Middle East — will experience extremely high water stress, increasing economic, social, and political tensions".[14] Countries already experiencing water stress or far worse include Egypt, Jordan, Turkey, Iraq, Israel, Syria, Yemen, India, China, and parts of the United States. The UN's Food and Agriculture Organization (FAO) forecasts that more than four billion people will be living under serious water shortages by the mid-2030s.

The projected 50% increase in demand for food by 2050 (compared to 2020) will entail a 20% increase in global water use. By 2050, the number of people facing acute water scarcity will have risen to five billion, warns UNESCO, and 1.8 billion people will be living in regions whose groundwater has run out, likely resulting in the large-scale displacement of people.[15]

The most recent IPCC report projects that up to 3 billion people are projected to experience chronic water scarcity due to droughts at 2°C warming, and up to 4 billion at 4°C warming, mostly across the subtropics to mid-latitudes.[16]

Scientists project the subtropical zone will experience a 5–10% reduction in precipitation for each degree Celsius of global warming. At 3°C of warming, water availability will decrease sharply in the dry tropics and subtropics, affecting about two billion people worldwide, and agriculture may become nonviable in the dry subtropics.[17]

India's national water supply is forecast to fall 50% below demand as early as 2030.[18] A World Bank report on China's water situation foresees "catastrophic consequences for future generations",[19] unless water use and supply can quickly be brought back into balance. Pakistan will face severe water scarcity by 2025 and is "one of the most water-stressed countries in the world".[20] In the Middle East and North Africa, drought is leading to instability and water weaponization.[21]

Climate change, drought and desertification can worsen water insecurity and trigger food crises, resulting in humanitarian disasters, instability and civil unrest, forced migration and internal displacement, and war within and across borders.

The Chatham House 2021 risk assessment notes that: "The global food crisis of 2007–08, caused by depleted grain stores, Australian drought and regional crop failures, led to a doubling of global food prices, export bans, food insecurity for importers, social unrest, and mass protests in countries including Cameroon, Egypt, Indonesia, Mexico, Morocco, Nepal, Peru, Senegal and Yemen."[22]

A US National Research Council report on the potential impacts of climate change on water security in the Hindu-Kush Himalayan region concluded that changes in the availability of water resources may play an increasing role in political tensions, especially if existing water management institutions do not evolve to take better account of the social, economic, and ecological complexities in the region. [23] But this analysis applies more broadly wherever water resources are shared across national boundaries.

Drought projections

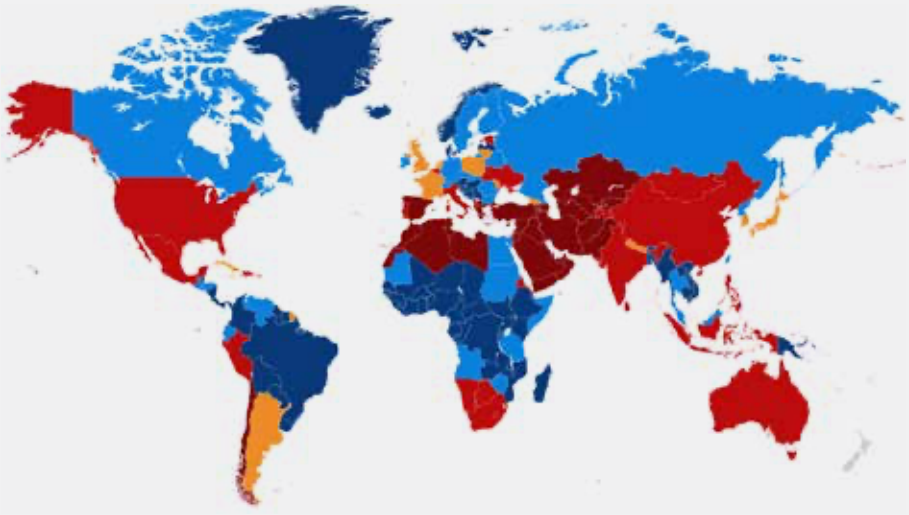
The Chatham House 2021 climate change risk assessment provides a central scenario in which emissions do not come down drastically before 2030, which is the path the world is currently on. The assessment paints the following picture of drought exposure by 2040–50:[24]

- By 2040, the average proportion of global cropland affected by severe drought (greater than 50% yield reductions) will likely rise to 32% a year, more than three times the historic average. By 2050 this increases to almost 40%.
- Europe has the second largest cropland area (20% of global total), and is likely to experience the largest increase in area affected by agricultural drought, and nearly half the cropland area will experience severe periods of drought by 2050. The figure for Africa is 44%.
- Assuming global cropland remains constant at 14.7 million square kilometres, by 2050 nearly 40% of that area will be exposed to severe drought for three months or more each year; however, this could reach just over 50% under the plausible worst-case scenario.
- By 2040, almost 700 million people a year are likely to be exposed to droughts of at least six months' duration, nearly double the global historic annual average. By 2040, North Africa, the Middle East, Western and Central Europe, and Central America will all see more than 10% of their populations impacted by prolonged severe drought. No region will be spared, but by 2040 East and South Asia will be most impacted with, respectively, 125 million and 105 million people likely to experience prolonged drought.
- Farmers in the worst-affected areas, including the critical breadbasket regions of southern Russia and the US, are likely to experience severe agricultural drought impacting 40% or more of their cropland area every year during the 2050s.
- Setting Asia aside, the continent with the greatest number of people likely to be impacted by hydrological drought is Africa, exceeding 180 million by 2050 under the central estimate.

Where water stress will be highest by 2040

Projected ratio of water withdrawals to water supply (water stress level) in 2040

- Extremely high (>80%)
- High (40-80%)
- Medium to high (20-39%)
- Low to medium (10-19%)
- Low (<10%)



(Source: World Resources Institute via The Economist Intelligence Unit)

FOOD SECURITY IN A HOTTER AUSTRALIA

Australia is the world's driest inhabited continent. 2019 was the hottest and driest year on record; New South Wales experienced the driest soil conditions on record, with farms devoid of stock, temperatures too hot for cattle to breed and east coast rivers ceasing to flow.

Food insecurity exists whenever the availability of nutritionally adequate and safe foods, or the ability to acquire acceptable food in socially acceptable ways, is limited or uncertain, according to the UN.[25] In Australia, food security is not measured at a population level regularly, however estimates suggest that 4–13% of the general population are food insecure, and 22–32% of the Indigenous population, depending on location.[26]

Demand for food both for domestic use and for export will increase in the future. Australia's population is projected to be almost 40% greater in 2050 compared to 2020; globally the figure is 24%, with global food demand around 50% higher by 2050.

Physical climate impacts in Australia include:

- Higher temperatures and increases in the intensity and frequency of hot days and heatwaves; more intense bushfires.
- A shift towards drier conditions across southwest and southeast Australia, with more frequent years of below average rainfall, especially for the cool season months of April–October.[27] In contrast, northern Australia has been wetter, but especially in the northwest during the northern wet season.[28] Mean rainfall will continue to decrease in southwest Australia, while changes over northern and eastern Australia remain uncertain.[29] There are no areas of likely increase. Projections for later this century show decreases in statewide annual average rainfall for all states, but there is significant uncertainty.[30]
- Increased evaporation due to higher temperatures.
- Increase in severity of droughts and the time spent in extreme drought conditions in southern Australia.
- Elevated levels of carbon dioxide.
- Increases in ocean temperatures and acidification, and rising sea-levels.

Impacts of climate change in Australia will be geographically variable but mostly negative for agriculture.[31] The physical changes will affect agriculture due to:

- Increased climate variability, with greater damage from severe storms, flooding and cyclones and more extreme heat, extensive droughts and heat stress affecting crops and animals. Heat stress reduces milk yield by 10-25% and up to 40% in extreme heatwave conditions; and the yields of many important crop species such as wheat, rice and maize are reduced at temperatures more than 30°C.[32]
- Increased erosion due to extended dry periods and faster rates of land degradation.
- Lower run-off and flows in water catchments in southern Australia: reduced irrigation allocations, water scarcity and increased climatic variability in the most productive agricultural regions, such as the Murray Darling Basin (MDB). (A 20% reduction in rainfall over the last hundred years in south-western WA has led to a 70% reduction in inflow to Perth dams).
- Reduction in broadacre livestock production in southern Australia.[33] Livestock carrying capacity will decrease across northern rangelands, given a "best estimate" for a decline (or little change) in rainfall and an increase in temperature.[34]
- Shorter growing season for cool season crops.
- Changed pest and disease regimes.
- Loss of pollinators from a combination of toxins in the environment, climate disruption, and changing land use practices.
- Higher level of photosynthesis and plant growth due to the CO_2 "fertilisation effect".
- Reduced fish stocks.

The 2022 IPCC impacts report says that disruption and decline in agricultural production and increased stress in rural communities is projected across south western, southern and eastern mainland Australia due to hotter and drier conditions, with Australia projected to experience a decline in crop and horticulture production.[35]

Murray-Darling Basin. The MDB accounts for approximately half of Australia's irrigated agricultural production. Prof. Ross Garnaut warned of the Basin's likely fate more than a decade ago: on a high-emissions trajectory, he said, irrigated agriculture output in the Basin would halve by 2050. And it would end by 2100, accompanied by a 40% drop in pasture productivity in south-eastern Australia.[36]

In fact, the reality is worse than the Garnaut's projections. CSIRO data shows that annual Basin water inflows have almost halved over the last 20 years.[37] Adding to the problem are market-driven practices that allocate declining water flows to high cash value crops including cotton, rather than to food production, at a time when Australia imports half of its rice.

By 2050, climate change is projected to halve the irrigated agricultural output of the Murray-Darling Basin region, which currently accounts for 50% of Australia's irrigated agricultural output by value (about $7.2 billion per year).[38]

Most of Australia can expect extreme temperatures of more than 50°C by century's end, and at 4°C of warming, annual rainfall in southern Australia may fall by half, particularly in winter and spring. Even a 2°C temperature rise, now likely before 2050, will make droughts 2.5 times more frequent.

Declining wheat production: Wheat is the major crop in Australia in terms of value, volume and area. Wheat-growing areas are feeling the brunt of climate change. Growing season rainfall across the wheat–sheep zone has been heavily skewed towards low rainfall over the past 20 seasons, according to ABARES.[39]

Australia's wheat yields more than trebled during the first 90 years of the 20th century but have stalled since 1990. The water-limited yield potential of wheat declined by 27% over a 26-year period from 1990 to 2015, due to reduced rainfall and rising temperatures, while the CO_2 fertilisation effect prevented a further 4% loss relative to 1990 yields.[40] Despite poorer conditions for growing wheat, farmers have managed to improve farming practices and at least stabilise yields.

And the future? Despite current good yields associated with La Niña conditions, researchers say that if the climate trend observed since 1990 continues, and farmers do continue to improve farming practices, then the national wheat yield will still fall from the recent average of 1.74 tonnes per hectare to 1.55 tonnes per hectare in 2041.[41]

The Climate Council reports that climatic challenges "could result in imports of key agricultural commodities such as wheat increasingly outweighing exports".[42] In Garnaut's hot, dry scenario, wheat yields fall to zero in many regions. The 2022 IPCC impacts report projects a decline in median wheat yields of up to 30% in south-west Australia by 2050, and a decline of 15% in South Australia.[43]

Export commodities: The loss of wealth from climate change impacts on agriculture and labour productivity may reach $A4.2 trillion by 2100 under a business-as-usual scenario, and estimates suggest that increasing drought frequency and impacts in the future may reduce GDP by 1% every year.[44] Over coming decades, agriculture production is expected to decline, with major export commodities including wheat, beef, dairy and sugar projected to fall 9-10% by 2030 and 13-19% by 2050. Overall declines of agriculture exports of 11-63% by 2030 and 15-79% by 2050 depend on the level of adaptation and warming.[45]

Supply chains: There is typically less than 30 days supply of non-perishable food and less than five days supply of perishable food in the supply chain at any one time. Households generally hold only about a 3–5 day supply of food. Such low reserves are vulnerable to natural disasters and disruption to transport from extreme weather.[46]

The impacts of more extreme events and unpredictable impacts on food production will lead to more price and supply volatility. Higher prices lead to food insecurity.

Australia's supply chains are precarious, being a geographical distant island in a hyper-connected global economy. Repeatedly over recent decades, the resilience of Australia's food supply chains have been tested by heavy rains and flooding. In early 2022, supermarket shelves lay empty as heavy rains disrupted both the east-west and north-south railway and road networks. Road trains bound for the Northern Territory and stranded on the flooded Stuart Highway were forced to take a 3,000-kilometre detour to deliver their cargo.[47] The problem was not lack of food but disruption to the supply chain required for its distribution. And this immediately after pandemic-caused labour shortages affected food supplies, distribution and prices.

A March 2022 report found that climate change is "heightening the risk of food shortages following extreme weather events"; that "empty supermarket shelves, once rare, will become a more common experience for Australians as the impacts of climate change worsen", and that climate change is also increasing the price of food, reducing availability of some lines. The report concludes that a lack of action "will make it virtually certain that in coming decades Australians will for the first time face the prospect of running out of food in our major towns and cities because supply chains fail".[48]

As well, there is strong evidence to suggest that climate change will impact the quality as well as quantity of food produced. The nutritional content of major food crops such as potatoes, wheat, corn, soybean and rice are likely to lower with increased atmospheric CO_2, potentially leading to deficiencies in iron, zinc and protein.[49]

The food security problem is made worse by current food systems which have contributed to environmental degradation and inequitable food distribution, overconsumption of foods in general (especially energy-dense nutrient-poor foods) and food waste.[50]

Photo: Sign on the road side in rural Australia.

"THE PROBABILITY OF SIMULTANEOUS DROUGHT ACROSS MULTIPLE REGIONS IS INCREASING... CONCURRENT CROP LOSSES IN MAJOR PRODUCTION REGIONS CAN CAUSE PRICE SPIKES AND HAVE CASCADING EFFECTS ON FOOD ACCESS, FAMINE AND FOOD RIOTS."

DR FRANZISKA GAUPP
ENVIRONMENTAL CHANGE INSTITUTE, UNIVERSITY OF OXFORD[51]

REGIONAL SNAPSHOTS

OVERVIEW

Food security in Asia will be affected not only by particular changes in the climate system, but by cascading and compound events. An overview is provided by Dr Robert Glasser, Head of the Climate and Security Policy Centre at the Australian Strategic Policy Institute:

"The frequency of El Niño events is expected to double under 1.5°C of warming — a level that could be reached within a decade — and both El Niños and La Niñas are likely to intensify. Consequently, the region will not only experience more severe extremes, but also more frequent swings from extreme heat and drought to severe floods. The diminishing time for recovery in between such events will have major consequences for food security and resilience. Crop yields will be reduced by rising temperatures, changes in rainfall, the expansion of the reach of crop pests and shifts in predators that keep crop pests in check.

"Scientists have determined that by 2040, at 2°C of warming, Southeast Asia's per capita crop production may decline by one-third. Climate impacts occurring outside of the region will further diminish the options available to countries to offset the domestic effects, such as by importing additional food, as Indonesia did on an unprecedented scale during its severe drought in 1998. Amplifying the food insecurity risks is the region's reliance on fisheries. Indonesia obtains more than half of its animal-source protein from fish, while in the Philippines the figure is about 40%. Fish species are already moving out of the region to escape warming waters, and the region's coral reefs, the 'nursery' for roughly 10% of the world's fish supply, are degrading rapidly; globally, over 90% of reefs will have collapsed at 1.5°C of warming."[52]

CORAL TRIANGLE

The Coral Triangle — encompassing Indonesia, Philippines, Malaysia, Papua New Guinea, the Solomon Islands and Timor Leste — contains 76% of the world's reef building corals and over 35% of the world's coral-reef fish species. It is the richest place on earth in terms of biodiversity. The 100 million people who live along the coasts of these islands depend on healthy ecosystems such as coral reefs, mangroves and seagrass beds to provide food, building materials, coastal protection, and support industries such as fishing and tourism.[53]

Coral reefs have provided food and resources for over 500 million people along tropical coastlines, as well as coastal protection against storm surges.[54] The world is on the precipice of losing its coral systems due to repeated bleaching and inadequate recovery times. At 1.5°C which is likely by 2030, coral reef coverage will be reduced by more than 99%.[55]

If the world's coral systems are lost, coastal ecosystems will only be able to provide 20–50% of the fish protein that they do today for those half a billion people.

THE HIMALAYAS & CENTRAL ASIA

The loss of the ice sheets (already well underway) in the Hindu Kush, Himalayan and Tibetan Plateau regions — where all the major rivers of Asia arise — will exacerbate regional geopolitical tensions as water shortages in India, Pakistan and China become more critical and dam construction and control of rivers flowing from the Himalayan plateau through several nations become flashpoints.

China has almost 20% of the world's population but less than 7% of potable water. There are long-standing border disputes between India, Pakistan and China, and all three are nuclear-armed. Water disputes between India and Pakistan have ebbed and flowed, even with the Indus Waters Treaty.[56]

China's cloud-seeding programs and attempts to hydro-engineer the sky could ease water shortages in the dry north of China but may exacerbate problems in south-east Asia and India if it affected the flow of the Mekong, Salween or Brahmaputra rivers - all of which have their sources on the Qinghai-Tibet plateau.

To the north-west, Central Asia, including Afghanistan, will suffer increasingly dire water insecurity, and internal displacement. Regional conflict over water rights is possible in this strategic zone that stretches to Iran.

There has been a shift westward of the Indian summer monsoon, and rainfall has become more variable. Pakistan may become a failed state, plagued by internal and neighbouring conflicts, acute water deficits, new heat extremes and a history of civilian society–military tensions.

CROPS YIELD TO THE HEAT

Compounding and cascading impacts of climate change will undermine food security on an increasing scale. To meet demand by 2050 — reflecting a larger population and a growing global middle class — agriculture will need to produce almost 50% more food by 2050 than in 2020. However, yields could decline by 30%[57] in the absence of dramatic emissions reductions, driven by increases in the frequency and probability of extreme drought and heat stress events in all regions of the world.[58]

Other climate factors impacting food security include the loss of corals and fish stocks in the Coral Triangle, ocean acidification, coastal inundation of agriculturally-rich river deltas, more extreme floods and cyclones, changed precipitation patterns, aridification, and more intense wildfires. Even without accounting for all these simultaneous hazards, scientists say that 2°C of warming around 2040 in Southeast Asia could reduce per capita crop production by one-third.[59]

As well, higher concentrations of CO_2 in the atmosphere are already having a serious effect on the nutritional quality of most of the world's major crops - grains, soya, corn and rice.[60]

Temperatures exceeding critical thresholds, especially during sensitive periods, may cause drastic drops of yield for wheat, maize and rice. Temperatures equal to or higher than 30-34°C at the time of flowering may inhibit pollen production and grain setting, giving unstable yields from year-to-year; lethal limits beyond which the plant dies are in the range of 45-47°C. The probability of crossing such thresholds in a given year — for example maize in the Midwestern US and rice in southern China — become increasingly significant with global temperature rise of more than 2°C, and in the worst cases to reach somewhere in the region of 25% (maize) and 75% (rice) respectively with global temperature rise of around 4-5°C.[61]

In terms of the risk of climate change to the production of individual crops, one thing to avoid is crop failure, so it is important to understand the plausible worst-case reductions in average yield. A high-level overview, in a 2016 UK climate risk assessment, provided some initial "worst-case" projections: by 2030-2049, the lowest tenth of projections give yield decreases of 25-50%: by 2090-2109, the lowest fifth of projections give yield decreases of 50-100%.[62]

Model-based research has found that anthropogenic climate change has reduced global agricultural total factor productivity by about 21% since 1961, a slowdown that is equivalent to losing the last seven years of productivity growth.[63] Researchers say that under current production systems and practises, food-climate models indicate aggregate crop yields in the USA could decrease during the end of the century (2050-2100) by 20-48% under a high-emissions scenario (RCP 8.5).[64]

A 2021 study, based on crop models, found that major breadbasket regions will face distinct anthropogenic climatic risks sooner than previously anticipated, and North and Central America, West Africa, Central Asia, Brazil, and China will potentially see their maize (corn) yields decline by up to 24%.[65] The study said wheat could potentially see yield growth of about 17%, however evidence suggests the yields for wheat and other major grain crops have levelled off over the last 20 years.[66]

The maize issue is critical because of the risk of a simultaneous crop failure across major producing countries, which would have devastating impacts on both supply and price, triggering social consequences reminiscent of the events of the Arab Spring. By the 2040s, the probability of a 10% or greater yield loss in any one year within the top four maize producing countries — the US, China, Brazil and Argentina which currently account for 87% of the world's maize exports — rises to between 40 and 70%. The probability of a synchronous, greater-than-10% crop failure across all four countries during the 2040s is just less than 50%, or almost one year in every two.[67]

REGIONAL SNAPSHOTS

PAKISTAN

Pakistan is a clear example of a country where the social and political landscape and susceptibility to climate harm are a potentially unstable mix. Increasing instability in Pakistan would contribute to the risk of instability in India and even China, which are key economic partners for Australia.

Pakistan is a pivot state between Central and South Asia. Salafist Islamist non-state actors play a significant role in conflict in Pakistan's immediate neighbourhood and within the country. Armed opposition groups target energy infrastructure, particularly in the China Pakistan Economic Corridor. The military and intelligence have a powerful say in Pakistani politics, and the Pakistani state has a direct interest in war-torn neighbouring Afghanistan and in disputed Kashmir. In addition, Pakistan is nuclear armed, as are neighbouring China and India.

Climate change has contributed to recent record-breaking drought events. On 30 May 2017, the thermometer in Turbat, Balochistan hit 54°C, the hottest reliably measured temperature ever recorded in Asia. In 2010, devastating floods affected one-fifth of the land area and 20 million people, destroyed 1.7 million homes, and damaged 5.4 million acres of arable land. The damage was made worse by a shift in the distribution of monsoonal rainfall to areas of the country with poorer flood mitigation measures.

Pakistan will face severe water scarcity by 2025 and is "one of the most water-stressed countries in the world"[68], driven by changing snow melt from the Himalayan/Karakoram ranges, more variable monsoons, increases in population, inefficient drainage practices, a shift in agriculture towards more water-intensive export cropping, and competing demands for water by the agriculture and power generation sectors.

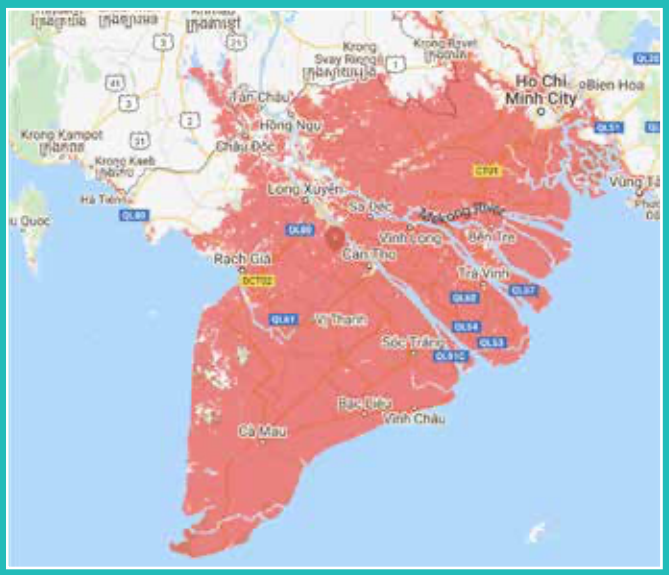
In quantitative terms, cubic yards of surface water available per person fell from 6,880 in 1951 some to 1,358 in 2010. By 2025 it is projected to decrease to 1,046 cubic yards.

VIETNAM

Vietnam is considered to be one of the most vulnerable countries for climate change impacts, including sea level rise, and increased frequency of natural disasters like typhoons, floods and droughts. Recently, climate change and disasters have negatively impacted some regions and caused household food insecurity, even though Vietnam is one of the best-performing nations on poverty reduction.[69] In 2015-16, the country experienced the strongest El Niño-induced drought, and the worst saltwater intrusion to date.

The Mekong Delta is the world's largest rice farming region, provides 40% of Vietnam's agricultural production, and more than half of national rice production and agricultural exports. Rice provides a national average 55% of total dietary energy.

Sixty per cent of Vietnam's urban areas are 1.5 metres or less above sea level, with the Mekong Delta very vulnerable to coastal inundation, being on average less than a metre above sea level. In recent years, Delta land subsidence has been drastically accelerated by humans due to unsustainable groundwater extraction, adding to its vulnerability. New flooding projections for the Mekong Delta in southern Vietnam, the world's largest rice farming region, show the entire area would be flooded annually by 2050 (see illustration).[70] A recent study identified 2050 as the tipping point by which stakeholders in the Mekong Delta will no longer be able to mitigate the issue of saltwater intrusion.[71]



Map: Mekong delta— projected to be below annual flood level in 2050. (Source: https://coastal.climatecentral.org, based on Kopp et a;. 2017.)

FOOD CRISES & SYSTEMIC RISK

In a complex world, social shocks are rarely singular in cause or effect. As with the physical world of climate change, disruption in one part of the system can cascade to produce a domino effect across the system as a whole, producing systemic risks.

Such risks may be defined as "risks that can trigger unexpected large-scale changes of a system, or imply uncontrollable large-scale threats to it" and arise from interactions between changes in the physical climate and human systems; in the present case not only the direct impacts of changes in the physical climate, but also the response of complex human systems such as the global economy, food markets, and the system of international security.[72]

Lloyds of London warns that a systemic shock to global food crop production "could have widespread economic, political and social impacts, including food price rises, food riots and changes in stock market values". Food system shock could trigger significant claims across multiple classes of insurance, compounded by the potential for the shock and its consequences to span multiple years.[73]

Climate disruption to food security, energy and water infrastructure could lead to business defaults on a scale that the insurance industry would be unable to cope with, and to significant falls in consumer spending: "Equity markets would also see abrupt shifts as a result of destruction of infrastructure and crops, leading to a sell-off of assets, declining equity prices, and shortfalls in pension funds, and ultimately undermining the financial markets, all of which would then spill over into the real economy."[74]

The FAO says that current patterns of agricultural intensification are not proving sustainable: "Pressures on land and water resources have built to the point where productivity of key agricultural systems is compromised and livelihoods are threatened. The interconnected systems of land, soil and water are stretched to the limit. Convergence of evidence points to *agricultural systems breaking down, with impacts felt across the global food system*" (emphasis added).[75]

Failure to understand this complexity will lead to an underestimation of the threat. ASPI's Dr Robert Glasser says it isn't surprising that the emerging threat to agriculture on our northern doorstep has been largely overlooked: "Most analyses of climate impacts treat climate hazards as independent variables rather than considering the wider context in which they interact with each other and with human systems. For example, a study of the impact that rising temperatures will have on agricultural productivity will overlook the compounding impacts of other hazards (flooding, drought, fires, increases of pests, saltwater inundation, cyclones, migrations of people, and so on), which will be occurring simultaneously."[76]

When diminished harvests occur for a number of different crops in the same time period, or across several major grain-growing regions for one crop at the one time, the impacts ricochet. As one example, concurrent climate-related wheat harvest failures in Ukraine, Russia and China were an important driver of The Arab Spring.

As described earlier, by the 2040s the probability of a synchronous, greater than 10% crop failure across the four top maize-producing countries is just less than 50%. In other words, almost one year in two would see a global maize supply crisis.

Globally, wheat and rice together account for 37% of people's calorific intake on average. Take the case of wheat and rice together, as analysed in the 2021 Chatham House risk assessment central (mid-range emissions reduction) scenario for 2050:

- More than 35% of the global cropland used to grow both these critical crops could be subject to damaging hot spells;
- South Asia is likely to be the most impacted, with more than 60% of winter wheat, spring wheat and rice exposed to damaging hot spells;
- These same global cropland areas will be impacted by reductions in crop duration periods of at least 10 days, exceeding 60% for winter wheat, 40% for spring wheat, and 30% for rice;
- More than 40% of African maize growing areas are likely to be subject to reductions in crop duration periods of at least 10 days;
- Nearly 75% of European winter wheat is subject to equally yield-reducing conditions (reductions in crop duration periods), up from almost 6% historically.[77]

This is a picture of sustained, simultaneous crop failures. As climate change increases the frequency of extreme weather events, what was once considered a "1-in-a-100 year" shock to global food production in the latter half of the 20th century may have become three times more likely by mid-century.

Globablisation has made countries more vulnerable to shocks in the global trade in food. One study concluded that: "...the global food system does exhibit characteristics consistent with a fragile one that is vulnerable to self-propagating disruptions. That is, in a setting where countries are increasingly interconnected and more food is traded globally over the [last two decades], a significant majority of countries are either dependent on imports for their staple food supply or would look to imports to meet any supply shortfalls."[78] This sets the scene for a plausible "worst-case" scenario, as illustrated in the box below.

A 2026 scenario

This scenario was developed by an expert panel in 2016.[79]

"It is our judgement that the combined production shock and responses in the 2016 plausible worst case scenario could see the FAO food price index reach record highs, surpassing 250 compared to around 170 at the time of writing, with a likely trebling in the price of individual grains. By way of comparison, the index reached 226 in 2008 and 238 in 2011. All other things being equal, the 2026 scenario would be expected to result in an even higher price spike.

"It is far from difficult to develop a plausible worst case scenario for 2026 in which system resilience is lowered over the next decade and macroeconomic conditions are unfavourable, making the global food system considerably more vulnerable to the same shocks. Factors that would cumulatively reduce the resilience of the global food system to supply shocks and increase the likelihood of a price crisis include: low stock-to-use ratios; the reduced self-sufficiency of China; increasingly inelastic demand; the recovery of oil prices; cumulative underinvestment in infrastructure in key exporting regions; and the depreciation of the US dollar. Under this set of preconditions the production shocks considered here would almost certainly result in a more dramatic price response.

"Consequently, the responses of societies and governments would likely be more extreme. A larger number of countries would probably experience civil unrest.

"The hardest impacts would be felt by import dependent developing countries, particularly in Sub-Saharan Africa. These countries would be expected to experience the most pronounced short-term deteriorations in poverty rates and nutrition security. At the economy level, impacts would likely include inflation, deteriorations in the balance of payments and budgetary pressures arising from higher food subsidies and social transfers.

"Other import dependent countries could experience social unrest. In particular, in the wake of the Arab Spring and ongoing instability in the region, the highly import dependent countries of the Middle East and North Africa region could be particularly vulnerable."

“CLIMATE DISRUPTION IS CAUSING HIGHER SURFACE TEMPERATURES, RISING SEA LEVELS, MORE FREQUENT AND SEVERE NATURAL HAZARDS, INCLUDING FLOODING, BUSHFIRES AND DROUGHT EVENTS. THESE, PLUS INCREASING DEFORESTATION, LAND-USE CONVERSION AND OCEAN ACIDIFICATION, WILL IMPACT UPON BIODIVERSITY AND ECOSYSTEMS AND INCREASE PRESSURES ON THE GLOBAL FOOD SYSTEM.”

PUBLIC HEALTH ASSOCIATION OF AUSTRALIA

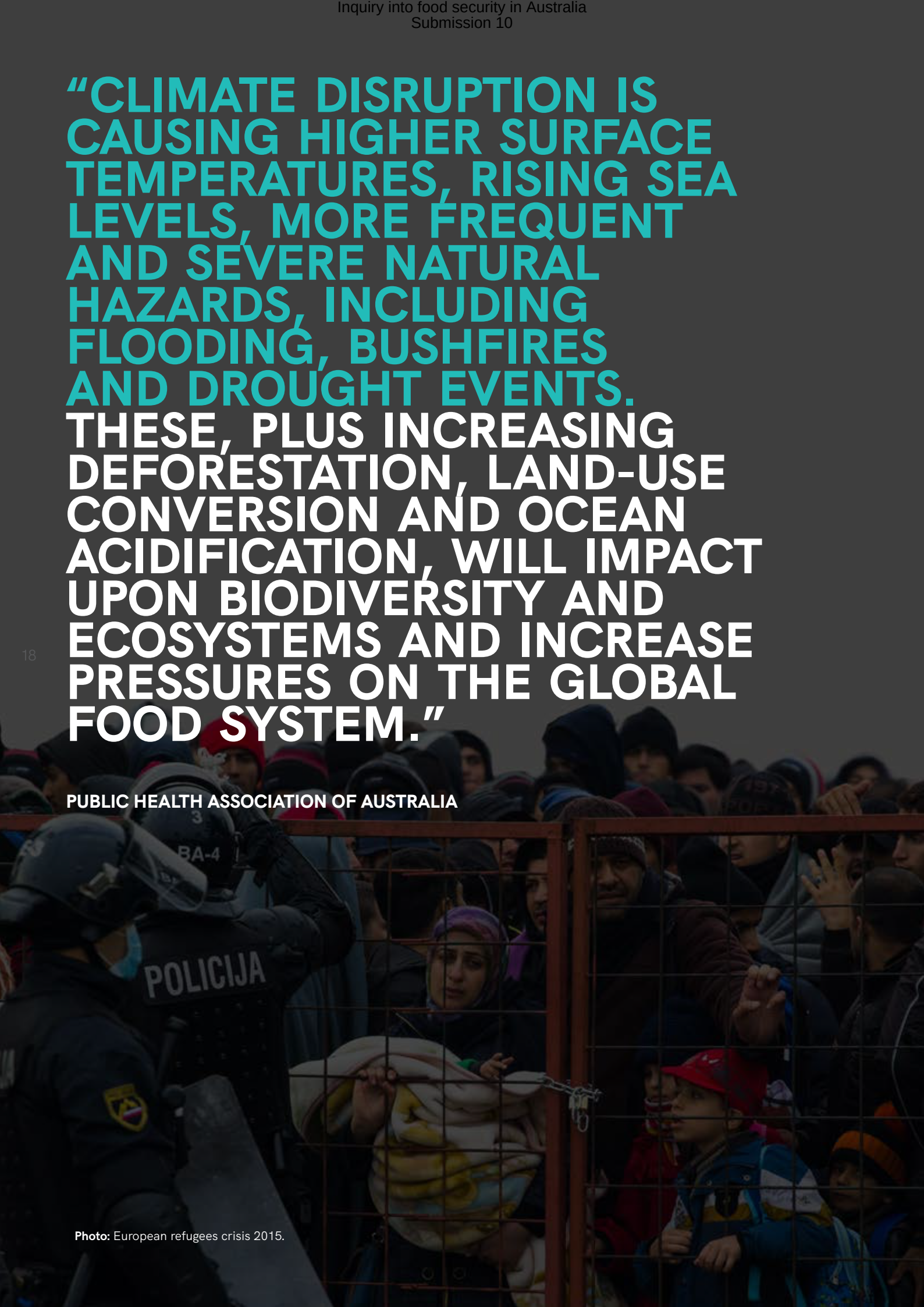


Photo: European refugees crisis 2015.

REGIONAL SNAPSHOTS

THE PACIFIC

Changing and more variable monsoon patterns and strong El Niños will add to the problem of water insecurity across Asia and the Pacific. As the climate becomes hotter, the dry season may extend in length, and droughts are likely to become more severe. Small-island developing states are especially vulnerable to the effect of drought and flooding on food production, which can affect the whole country. A strong El Niño in 2015-16 caused significant drought and frosts across Melanesia, with negative impacts on agriculture, water supply, women's labour and villagers' health.

By late 2015, a maximum of 770,000 people in Papua New Guinea — nearly 10% of the population — were living in locations where food was very scarce or extremely scarce. Depletion of fisheries by big-power fleets is adding to food insecurity, whilst rising sea levels will inundate crops and gardens. Coastal inundation and more intense cyclone damage can overwhelm authorities' capacity to respond across the full extent of the affected zone. Communities abandoned by the triage process, which prioritises some areas over others and neglects some of the most vulnerable, may become angry and riot, often motivated by water and/or food insecurity.

CHINA

Before he became China's premier, in 1999, Wen Jiabao warned that water scarcity posed one of the greatest threats to the "survival of the nation". With a booming economy, land conversion and water scarcity, that threat looms ever larger.

Chinese food production could reduce substantially in the coming decades. Per-capita cereal production, compared to 2000, could fall 18% by the 2040s. By 2030–2050, loss of cropland resulting from urbanisation and soil degradation could cut food production capacity 13–18%, compared to 2005. These declines could result in "continued or recurring food shortages" posing a "substantial threat to overall community health and well-being, social stability and human nutrition".[80]

Four-fifths of China's grain harvest comes from irrigated land, most of it drawing on surface water, principally the Yellow and Yangtze rivers, which are fed from the Tibetan Plateau. The water table under the North China Plain, an area that produces half of the country's wheat and a third of its corn, is falling fast. Overpumping has largely depleted the shallow aquifer, forcing well-drillers to turn to the region's deep aquifer, which is not replenishable. A World Bank report on China's water situation foresees "catastrophic consequences for future generations",[81] unless water use and supply can quickly be brought back into balance.

China currently employs around 25,000 people in cloud seeding programs. These in part are designed to push atmospheric moisture from the Tibetan Plateau north onto the plains. But the grasslands of northern China and Mongolia could be about to lurch into a climate tipping point, an irreversible sequence of heat and drought.[82]

PHILIPPINES

The Philippines' food production system, as well as its villages and rural areas, are highly exposed to the impacts of climate change and natural hazards. About one-quarter of Filipinos live below the poverty line, making the country vulnerable to food price and supply shocks.

In 2015, the Philippines was ranked as the fifth most affected nation by climate-related disasters between 1994 and 2013. Oceans to the east of the Philippines are the most rapidly warming surface water anywhere in the world, driving record-breaking cyclones such as Typhoon Haiyan in 2013, which was the most powerful tropical cyclone to make landfall in recorded history. Manila is rated as the second-most-at-risk city to climate change in the world, in the "extreme" category in 2013, in part due to the threat from rising sea levels

Government officials warn that more destructive El Niño and La Niña cycles directly threaten agricultural production and food security which will be impacted by extreme flooding, prolonged and intensified droughts, more powerful typhoons, and intense storm surges.[83] Climate change will have a modestly negative effect on rice, sugarcane, and bananas and a slightly positive effect on coconuts, but a large and negative effect on maize. Modelling results indicate that "the prices of agricultural food commodities will be considerably higher in 2030 and 2050 relative to what they would have been without climate change and that these price increases will disproportionately affect poor people. World prices of most food commodities are projected to rise, which will have flow-on effects for Philippine food prices."[84]

ACT NOW TO MITIGATE THE LOOMING CRISIS

Climate change poses an increasing threat to peace, can undermine livelihoods, increase involuntary migration and reduce the ability of states to provide security. It can amplify existing vulnerabilities, especially where there is existing conflict and weak or failing governments, thus exacerbating or "multiplying" the negative effects of other drivers of change, and disproportionately affecting the more vulnerable.

The 2022 IPCC impacts report says that climate change and extreme weather events and temperatures "have exposed millions of people to acute food insecurity and reduced water security" and malnutrition. Agriculture is seeing losses and fisheries are in decline in some regions. Migration tied to climate shifts is rising.[85]

Australia and the Asia-Pacific region are a "disaster alley" for climate change, with more than half the world's population, low-lying small-island states, and most of the large cities vulnerable to sea-level rise. Nations in the Coral Triangle face the loss of their coral systems, the region's most populous nations — India and China — will face increasing chronic water insecurity, and more extreme heatwaves will become unbearable in South and Southeast Asia.

The consequences for Australia will be enormous: displaced people and nations, the economic impacts on major trading partners, supply chain disruption, geopolitical tensions, the need for more development support, and increasing demands for humanitarian aid and disaster relief.

There will be increasing calls on the military for support and humanitarian aid, including in their own countries, such as that required in response to the record-breaking "Black summer" bushfires in Australia in 2019-20. Armed forces have, and will continue to, adapt to this changing environment, and consider climate change impacts on infrastructure, installations, equipment and the capacity of personnel to operate in more extreme climate conditions. The failure to address the root causes of climate warming will result in great pressure on the Australian Defence Force and emergency and disaster relief agencies to pick up the pieces in the face of accelerating climate impacts. Higher levels of warming may stretch them beyond their capacity to respond.

Prof. Brendan Sargeant has argued that climate change is a system-wide challenge for which no single country can resolve without the assistance of other countries:

> "Climate change emphasises the interdependencies of countries and the need to respond in an integrated way that ensures that each country's individual response strengthens the response of all countries. As a security issue, climate change challenges traditional security frameworks that privilege national interests over the collective interest. Traditional security frameworks bias policy towards national responses that focus on the manifestations of climate change, rather than the causes. If climate change is the existential threat, then all other policy frameworks that might shape security agendas become subordinate."[86]

In this context, and facing climate-change enhanced global food crises, the world needs to establish methods to better forecast potentially disruptive climate change events — such as severe drought — well in advance. Such a facility may have helped prevent or mitigate the Syrian disaster. Only then can the capacity be developed to reduce risks through building global and community resilience and strength before the world encounters systemic food crises.

Strengthening the resilience of vulnerable nations to climate impacts is critical; however this will only reduce long-term risk if improvements in resilience are accompanied by strong actionable agreements to stabilise the climate.

The first duty of government is the safety and protection of the people, but Australia has failed when it comes to climate change threats. Australia has no credible climate policy, leaving our nation unprepared for increasingly harsh climate impacts. Climate change should be a primary focus of both economics and politics in Australia, with clear commitments to mobilise the resources necessary to address this clear and present danger.

There is nothing more important for our survival and future prosperity. It is already too hot and climate change is already dangerous. Fossil fuel emissions must be reduced to zero at emergency speed. The goal of net zero emissions by 2050 is wholly inadequate; that point must be reached as close to 2030 as possible.

Responding effectively to climate change requires greatly increased co-operation globally, regionally and among Australian institutions, to build more resilient communities. It is time to act with clarity and urgency.

FOOTNOTES

1 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

2 Frimpong, OB 2020, Climate change and violent extremism in the Lake Chad basin: Key issues and way forward, Occasional Paper, The Wilson Center, Washington DC

3 Cox, K et al. 2020, A changing climate: Exploring the implications of climate change for UK defence and security, RAND Corporation, Santa Monica CA and Cambridge Cambs.

4 Quiggin, D et al. 2021, Climate change risk assessment, Chatham House, London

5 Standish, R 2002, 'Could The War In Ukraine Trigger A Global Food Crisis?, Radio Free Europe, 27 March

6 Terazono, E & Pooler, M 2022, ' Wheat prices hit record highs as war halts exports from Ukraine and Russia', Financial Times, 4 March

7 Benton, T et al. 2022, 'Ukraine crisis could trigger cascading risks globally', Chatham House, 16 March

8 Evans-Pritchard, A 2022, "Leaders are getting scared': Putin's war and La Niña could set off global food emergency", The Age, 10 May

9 Steinbruner, JT et al. 2013, Climate and social stress: Implications for security analysis, The National Academies Press, Washington DC

10 Wolf, AT 2007, 'Shared waters: Conflict and cooperation', Annual Review of Environment and Resources, vol. 32, pp. 241-269

11 King, D et al. 2016, Climate change: A risk assessment, Centre for Science and Policy, University of Cambridge, Cambridge Cambs.

12 CNA 2014, National security risks and the accelerating risks of climate change, CNA Military Advisory Board, Alexandria VA

13 Addams, L et al. 2009, Charting our water future: Economic frameworks to inform decision-making, Water Resources Group/McKinsey & Company, New York NY

14 NIC 2017, Global trends: Paradox of progress, US National Intelligence Council, Washington DC

15 Cribb, J 2019, Food or war, Cambridge University Press, Port Melbourne Vic.

16 Howden, M et al. 2022, 'Mass starvation, extinctions, disasters: the new IPCC report's grim predictions, and why adaptation efforts are falling behind', The Conversation, 28 February.

17 Campbell, KM et al. 2007, The age of consequences: The foreign policy and national security implications of global climate change, Centre for Strategic and International Studies/Center for New American Security, Washington DC

18 Ahmed, NM 2017, Failing states, collapsing systems: Biophysical triggers of political violence, Springer Briefs in Energy, Cham Switzerland

19 Brown, L 2013, 'The real threat to our future is peak water', The Guardian, 6 July 2013

20 World Bank 2005, Pakistan country water resources assistance strategy — Water economy: Running dry, Report 34081-PK, World Bank, Washington DC

21 King, MD & LeHane, R 2021, 'Drought is leading to instability and water weaponization in the Middle East and North Africa', The Center for Climate and Security, 30 April

22 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

23 Steinbruner, JT et al. 2013, Climate and social stress: Implications for security analysis, The National Academies Press, Washington DC

24 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

25 FOA 2012, Coming to terms with terminology, Food and Agricultural Organisation of the United Nations, Rome IT

26 Bowden, M. 2020, Understanding food security in Australia, CFCA Paper No 55, Australian Institute of Family Studies, Southbank Vic.

27 Nelson, R et al. 2020, 'Seasonal climate scenarios for medium-term forecasts', Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra ACT

28 BOM 2021, 'State of the climate 2020', Bureau of Meteorology, www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml

29 Dey, R et al. 2019, 'A review of past and projected changes in Australia's rainfall', WIREs Climate Change, vol. 10, doi. org/10.1002/wcc.577

30 Garnaut, R 2008, The Garnaut Climate Change Review: Final report, Cambridge University Press, Port Melbourne Vic.

31 Head, L et al. 2014, 'Climate change and Australia', WIREs Climate Change, vol. 5, pp. 175-197

32 Hughes, L et al. 2015, Feeding a hungry nation: Climate change, food and farming in Australia, Climate Council, Sydney NSW

33 Moore, AD & Ghahramani, A 2013, 'Climate change and broadacre livestock production across southern Australia. 1. Impacts of climate change on pasture and livestock productivity, and on sustainable levels of profitability', Global Change Biology, vol. 5, pp. 1440-1445

34 McKeon, GM et al. 2009, 'Climate change impacts on northern Australian rangeland livestock carrying capacity: A review of issues', The Rangeland Journal, vol. 31, pp. 1-29

35 IPCC 2022, Climate change 2022: Impacts, adaptation and vulnerability, The Working Group II contribution to the Sixth Assessment Report, Intergovernmental Panel on Climate Change, WMO/UNEP, Geneva.

36 Garnaut, R 2008, The Garnaut Climate Change Review: Final report, Cambridge University Press, Port Melbourne Vic.

37 Long, W 2021, 'CSIRO predicts more drought, drastic drop in Murray-Darling basin water', ABC Rural, 30 May

38 Steffen, W et al. 2019, Compound Costs: How climate change is damaging Australia's economy, Climate Council, Sydney NSW

39 Nelson, R et al. 2020, 'Seasonal climate scenarios for medium-term forecasts', ABARES Agricultural Commodities, March quarter

40 Hochman, Z et al. 2017, 'Climate trends account for stalled wheat yields in Australia since 1990', Global Change Biology, vol. 23, pp. 2071-2081

41 Hochman, Z et al. 2017, 'Changing climate has stalled Australian wheat yields: study', The Conversation, 25 January

42 Hughes, L et al. 2015, Feeding a hungry nation: Climate

change, food and farming in Australia, Climate Council, Sydney NSW

43 IPCC 2022, Climate change 2022: Impacts, adaptation and vulnerability, The Working Group II contribution to the Sixth Assessment Report, Intergovernmental Panel on Climate Change, WMO/UNEP, Geneva.

44 Steffen, W et al. 2019, Compound Costs: How climate change is damaging Australia's economy, Climate Council, Sydney NSW

45 Gunasekera, D et al. 2007, 'Climate change: impacts on Australian agriculture.' Australian Commodities, vol. 14, pp. 657-676

46 Hughes, L et al. 2015, Feeding a hungry nation: Climate change, food and farming in Australia, Climate Council, Sydney NSW

47 Gooch, D et al. 2022, 'Territory-bound road trains blocked by flooded Stuart Hwy make 3,000km detour', ABC News, 26 January

48 Bartos, S 2022, Fork in the road: Impacts of climate change on our food supply, Farmer for Climate Action

49 Fanzo, J et al. 2018, 'The effect of climate change across food systems: Implications for nutrition outcomes', Global Food Security, vol. 18, pp. 12-19

50 PHAA 2018, Climate disruption, the food system and food security: Policy position statement, Public Health Association Australia, Deakin ACT

51 Langenbrunner, B 2021, 'Water, water, not everywhere', Nature Climate Change, vol. 11, pp. 650

52 Glasser, R 2021, The rapidly emerging crisis on our doorstep, Strategic Insight 157, Australian Strategic Policy Institute, Barton ACT

53 Hoegh-Guldberg, O et al. 2009, The Coral Triangle and climate change: Ecosystems, people and societies at risk, WWF Australia, Brisbane Qld

54 Hoegh-Guldberg, O 2010, 'Coral reef ecosystems and anthropogenic climate change', Regional Environmental Change, vol. 11, pp. 215–227

55 Dixon, AM et al. 2022, 'Future loss of local-scale thermal refugia in coral reef ecosystems', PLOS Climate, vol. 1, art. e0000004.

56 Watts, J 2020, 'China plans rapid expansion of "weather modification" efforts', The Guardian, 4 December

57 Global Commission on Adaptation 2019, Adapt now: A global call for leadership on climate resilience, Global Commission on Adaptation, Rotterdam NL

58 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

59 Glasser, R 2019, Preparing for the era of disasters, Special report, Australian Strategic Policy Institute, Barton ACT

60 Porritt, J 2020, Hope in hell: A decade to confront the climate emergency, Simon & Schuster, London UK

61 King, D et al. 2016, Climate change: A risk assessment, Centre for Science and Policy, University of Cambridge Cambs.

62 King, D et al. 2016, Climate change: A risk assessment, Centre for Science and Policy, University of Cambridge Cambs.

63 Ortiz-Bobea, A, et al. 2019, 'Anthropogenic climate change has slowed global agricultural productivity growth', Nature Climate Change, vol. 11, pp. 306–312

64 Ortiz-Bobea, A, et al. 2019, 'Unpacking the climatic drivers of US agricultural yields', Environmental Research Letters, vol. 14, art. 064003

65 Jägermeyr, J 2021, 'Climate impacts on global agriculture emerge earlier in new generation of climate and crop models', Nature Food, vol. 2, pp. 873–885

66 Smil, V 2021, Growth: From micro-organisms to megacities, Random House, New York NY

67 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

68 World Bank 2005, Pakistan country water resources assistance strategy — Water economy: Running dry, Report 34081-PK, World Bank, Washington DC.

69 Dao, TA & Pham, CN 2020, 'New food challenges for Vietnam', FFTC Agriculture Policy Platform, Taipei, Taiwan, 31 July

70 Kulp, SA & Strauss, BH 2019, 'New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding', Nature Communications, vol. 10, art. 4844

71 Eslami, S 2021, 'Projections of salt intrusion in a mega-delta under climatic and anthropogenic stressors', Comm. Earth & Envir, vol. 2, art. 142

72 King, D et al. 2016, Climate change: A risk assessment, Centre for Science and Policy, University of Cambridge Cambs.

73 Lloyds 2015, Food system shock: The insurance impacts of acute disruption to global food supply, Lloyd's Emerging Risk Report – 2015, Lloyds, London UK

74 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

75 FAO 2021, The state of the world's land and water resources for food and agriculture: Systems at breaking point, Synthesis report 2021, Food and Agriculture Organisation of the United Nations, Rome IT

76 Glasser, R 2021, The rapidly emerging crisis on our doorstep, Strategic Insight 157, Australian Strategic Policy Institute, Barton ACT

77 Quiggin, D et al. 2021, Climate change risk assessment 2021, Chatham House, London UK

78 May, RM 2013, 'Networks and webs in ecosystems and financial system', Philosophical Transactions of the Royal Society A, vol. 371, art. 20120376.

79 King, D et al. 2016, Climate change: A risk assessment, Centre for Science and Policy, University of Cambridge Cambs.

80 Tong, S et al. 2016, 'Climate change, food, water and population health in China', Bulletin of the World Health Organization, vol. 94, pp. 759 - 765

81 Brown, L 2013, 'The real threat to our future is peak water', The Guardian, 6 July

82 Tim Radford, T 2020, 'China and Australia face a climate tipping point, Climate News Network, 10 December

83 Romero, P 2016, 'Climate change threatening Philippines's food security', The Philippine Star, March 27

84 Thomas, TS 2016, Agricultural growth, climate resilience and food security in the Philippines, Climate Change Policy Note 2, International Food Policy Research Institute, Washington DC

85 IPCC 2022, Climate change 2022: Impacts, adaptation and vulnerability, The Working Group II contribution to the Sixth Assessment Report, Intergovernmental Panel on Climate Change, WMO/UNEP, Geneva.

86 Sargeant, B 2021, The implications of climate change for Australian strategic and defence policy in relation to the alliance and Pacific island states, Regional Outlook Paper No. 68, Griffith Asia Institute, Nathan Qld

ABOUT THE ASLCG

The ASLCG Executive membership comprises senior leaders with a depth of career experience in defence, national security, policy and risk assessment.

Admiral Chris Barrie AC (Retd) is former Chief of the Defence Force. Chris Barrie retired in 2002 after 42 years in the Royal Australian Navy (RAN). Since then, he has worked on strategic leadership issues as consultant, teacher and mentor at Oxford University, the National Defense University in Washington DC and at the Australian National University.

Air Vice-Marshal John Blackburn AO (Retd) is former Deputy Chief of the Royal Australian Air Force and currently the Chair of the Institute for Integrated Economic Research-Australia and also a consultant in the field of defence and national security. He has extensive experience across the fields of strategy, policy, planning, operational command, capability development and materials acquisition.

Colonel Neil Greet (Retd) is a former Australian Army officer with operational service in Iraq and Timor Leste, who led projects in several remote indigenous communities and played a key role in Defence's response to Victoria's 2009 Black Saturday disaster. He is a Director of the Institute of Integrated Economics Research, and the consultancy Collaborative Outcomes.

Cheryl Durrant is former Director of Preparedness & Mobilisation, Australian Department of Defence, and was the Defence partner with the Australian National Resilience Taskforce's Disaster Vulnerability Profiling Project. Cheryl served 15 years with the Australian Army, specialising in strategic intelligence, information operations and domestic security.

Major Michael Thomas (Retd) a former Australian Army officer and is a non-resident Senior Fellow with the Washington-based Center for Climate & Security where he co-leads the Indo-Pacific Program. He is also a council member with the International Military Council on Climate and Security and author of *The Securitisation of Climate Change* (2017).

Ian Dunlop is a Member of the Club of Rome. He was formerly an international oil, gas and coal industry executive, chair of the Australian Coal Association, CEO of the Australian Institute of Company Directors, and chair of the federal government's first emissions trading taskforce, with wide experienced in risk management.

AUSTRALIAN
SECURITY
LEADERS
CLIMATE
GROUP