Adapting Food Systems to a Changing Climate

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Abstracts

Climate change, including the increasing frequency and magnitude of climate extremes, has already negatively impacted food systems, undermining food security and nutrition. In 2022, the Intergovernmental Panel on Climate Change (IPCC) released the 6th Assessment Report (AR6) on climate change impacts, adaptation, and vulnerability to provide science-based and policy-relevant information. The report chapter comprehensively covers food, fibre, and other ecosystem service climate change impacts, projected risks, and adaptation solutions, leading to more resilient food systems[1].

The assessment in the chapter highlights the significant impacts that human-induced climate change, including extreme weather events, is having on food systems. These impacts include reduced productivity, declining food quality, and changes in species distributions, increasing the risks of malnutrition and resource competition, especially for vulnerable populations. Since the mid-20th century, the growing frequency of extreme events has resulted in sudden losses in food production, decreased availability, and rising food prices, leading to acute food insecurity and worsened livelihoods in many regions. While autonomous adaptation measures have been adopted in agriculture and aquatic food production, they often remain incremental and limited to specific sectors.

Ecosystem-based approaches, such as diversification, land restoration, agroecology, and agroforestry, can enhance food production while offering multiple benefits, including improved yield stability and ecosystem health. Sustainable management of resources in response to shifts in species distribution—both terrestrial and aquatic—due to climate change is an effective adaptation measure to mitigate risks to food security and nutrition. Increasing global warming levels will constrain these options, putting food security at even greater risk in vulnerable areas.

Overall, substantial mitigation efforts are required to minimize the impacts on food systems and the ecosystems that support them. Food systems contribute around 30% of total human-caused emissions, and adaptation and mitigation actions that overlook ecosystem functions and equity could worsen the negative impacts of climate change, increasing vulnerability in certain regions and groups. In contrast, some adaptation strategies can enhance the sustainability of food production, reduce vulnerabilities, and improve ecosystem health in the context of climate change. Societal changes, such as shifts in dietary patterns, are also explored, as well as the risks of maladaptation and approaches to avoid it, with the goal of ensuring fair food distribution. This presentation summarizes key messages from the IPCC AR6 and discusses strategies for using genetic resources to enhance the resilience of food systems in the face of climate change.

[1] Bezner Kerr, R. et al. Food, Fibre, and Other Ecosystem Products, in: Pörtner, H.O. et al. (Eds.), Climate Change 2022: Impact, Adaptation, And Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press (CUP), Cambridge, UK and New York, NY, USA, pp. 713–906 (2022) https://doi.org/10.1017/9781009325844.007

November 22, 2024
JIRCAS Symposium 2024, titled 'Resilient Genetic Resources for Food Security in the Era of Global Boiling – Opportunities and Challenges for Conservation and Utilization'

NARO

Adapting food systems to a changing climate

-Key Messages from the IPCC Working Group 2 6th Assessment Report (AR6) -

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Outline

1. Observed impacts of climate change (CC) on agricultural production
2. Projected impacts and associated risks
3. Adaptation action
   - Potentials and limits to adaptation (quantitative studies)
   - Research gaps
4. Maladaptation
5. Conclusion

SIXTH ASSESSMENT REPORT

IPCC

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Food, fibre, and other ecosystem products

Chapter 5 provides a global assessment of climate change impacts and risks to agriculture, forestry, fisheries and aquaculture, as well as adaptation solutions and limits.

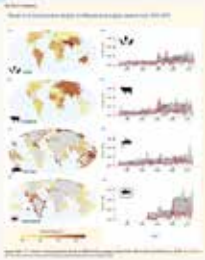
SIXTH ASSESSMENT REPORT

IPCC

1. Observed impacts CC

Compared with the previous report, **more robust & widespread evidence of observed impacts,** particularly around **climate-related hazards**

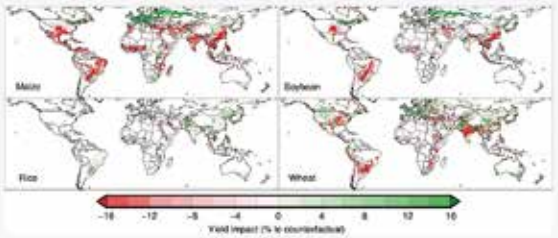
- Increasing extreme events have exposed millions of people to acute food insecurity, with the largest impacts are observed in many locations and/or communities in Africa, Asia, Central and South America, Small Islands and the Arctic.
- Climate change has slowed the agricultural growth over the past 50 years globally with regionally different impacts.
- Vulnerable groups, such as women, children, low-income households, Indigenous or other minority groups and small-scale producers, are often at higher risk of malnutrition, livelihood loss, rising costs and competition over resources.



Human-induced climate change impacts on four major crops

NARO

Estimated impacts of climate change on average yields for 1981–2010.
Positive values indicate that climate change has increased the yields, and negative values indicate that climate change has decreased the yields relative to what would have occurred without climate change. errors



Izumi et al. (2018) International Journal of Climatology, Volume: 38, Issue: 14, Pages: 5405-5417, First published: 20 August 2018, DOI: (10.1002/joc.5818)

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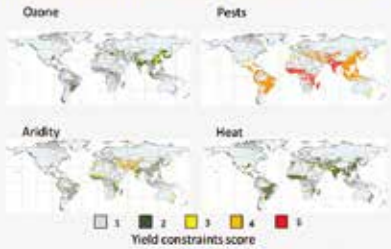
IPCC

Current yield losses by factors (rice)



The global effects of five biotic and abiotic stresses on soybean and wheat. All data are presented for the 1 × 1° (latitude and longitude) grid squares where the mean production of soybean or wheat was >500 tonnes (0.0005 Tg).
The effect of each stress on yield is presented as a Yield Constraint Score (YCS) on a scale of 1–5, where 5 is the highest level of stress from ozone, pests and diseases, heat stress and aridity.

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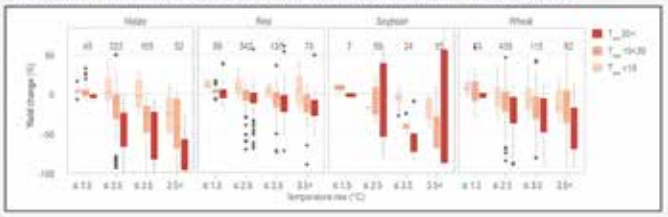
2. Projected impacts

Projected yield changes of the four major crops relative to the baseline period (2001-2010) without adaptation and with CO_2 fertilization effects in response to temperature rise from the pre-industrial era (1850-1900).



(IPCC AR6 Chapter 5)

- The impacts differed depending on the regions associated with the current temperature levels.
- Even small degree of warming might cause highly negative impacts in currently warm regions such as the tropics.

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Many risks are compounding and cascading:

IPCC AR6 WG2

See also this for a review on **breadbasket failures.**
Hasegawa, T., Wakatsuki, H., Nelson, G.C., 2022. Evidence for and projection of multi-breadbasket failure caused by climate change. Curr. Opin. Environ. Sustain. 58, 101217. https://doi.org/10.1016/j.cosust.2022.101217

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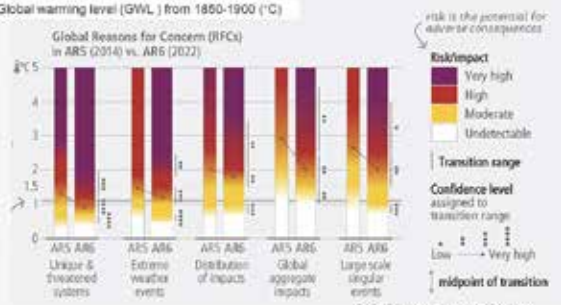
Global warming level (GWL) from 1850-1900 (°C)

Risk transitions are projected to occur at lower GWLs than in AR5.

Warming level in 2011-2020



IPCC AR6 Synthesis report SPM figure

SIXTH ASSESSMENT REPORT

3. Adaptation action

Ongoing adaptation action

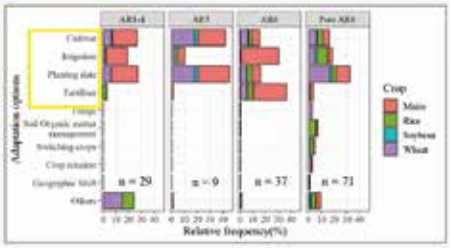
Effective options:

- Cultivar improvements
- Agroforestry
- Farm and landscape diversification
- Community-based adaptation
- Strengthening biodiversity

Wider benefits:

- Food security and nutrition
- Health and well-being
- Livelihoods

Some adaptations effects are quantified



A systematic review for the crop simulation studies (Wakatsuki et al., 2023)

Cultivars are often tested, primarily to adjust and/or optimize their phenology for changing climates.

Few sustainable management practices have been quantitatively assessed using simulation models, but new studies such as 'agroforestry', 'organic farming', 'climate-smart agriculture', and 'cropping system diversification' are emerging.

Wakatsuki et al., 2023. Curr. Opin. Environ. Sustain. 60, 101249. https://doi.org/10.1016/j.cosust.2022.101249

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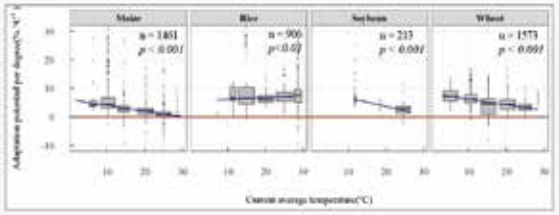
Adaptation potentials / limits

- **"Adaptation potential** is defined as the difference in simulated crop yield impacts with and without adaptation.
- For the upland crops, adaptation potential (% °C^{-1}) was approximately 4 -5% at 15 °C but more than halved at 30 °C
- The capacity to offset adverse impacts is limited in warmer regions with the current adaptation options.



Wakatsuki et al. 2023 Current Opinion in Environmental Sustainability

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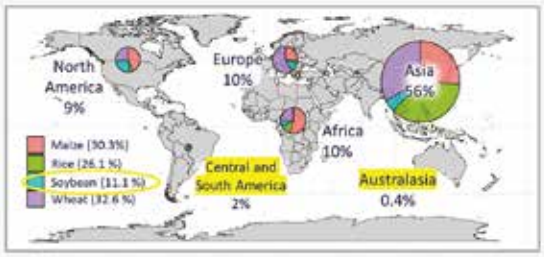
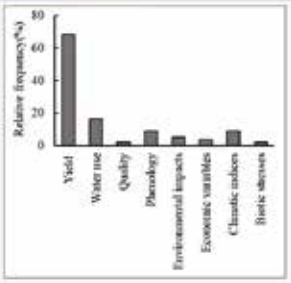
Research gaps in quantitative evaluations 1



Wakatsuki et al. 2023 Current Opinion in Environmental Sustainability (https://doi.org/10.1016/j.cosust.2022.101249)

Research gaps in quantitative evaluations 2



- 'Yield' remains the major target
- Climate and weather extremes and related yield losses are becoming another major topic
- Pest and Diseases
- Quality

Wakatsuki et al. 2023 Current Opinion in Environmental Sustainability (https://doi.org/10.1016/j.cosust.2022.101249)

SIXTH ASSESSMENT REPORT — ipcc

Systematic review provides evidence of synergies of adaptation with SDGs.

IPCC WG2 AR6 Chp. 5

SIXTH ASSESSMENT REPORT — 4. Maladaptation — ipcc

More evidence of **adaptation limits, maladaptation** and **financial constraints**

Limits to adaptation

Even effective adaptation cannot prevent all losses and damages, and limits will be reached at higher levels of global warming.

e.g.

- By 2°C it will be challenging to farm in some staple crops in many current growing areas.

Maladaptation

Adaptation that results in unintended consequences. The most disadvantaged groups are most affected.

e.g.

- Large-scale and/or groundwater-dependent irrigation projects or programs can reduce long-term availability and increase salinity and water costs.
- Migration can increase the workload of those left behind (often women), exacerbating rural livelihoods and food insecurity.

Financial constraints

- Current global financial flows are insufficient
- Most finance targets emissions reductions rather than adaptation
- Climate impacts can slow down economic growth

Potential pathways leading to mal-adaptations in food systems

Maladaptation may be avoided if actions are designed/created by multiple stakeholders considering multiple dimensions.

Bezner Kerr, R., 2023. Maladaptation in food systems and ways to avoid it. Curr. Opin. Environ. Sustain. 61, 101269. https://doi.org/10.1016/j.cosust.2023.101269

5. Conclusions

- Climate change driven by human activity poses a significant threat to sustainable and resilient food systems.
- Genetic improvements are a key adaptation strategy, but their effectiveness must be tested under varying levels of hazard exposure.
- Adopting improved cultivars can lead to maladaptive outcomes if equity issues, such as access to resources, are not adequately addressed.
- There are clear limits to adaptation, and further delays in climate action will reduce opportunities to implement effective measures to build resilient food systems.