Food and Agriculture Organization of the United Nations

WORLD METEOROLOGICAL ORGANIZATION

HIGHLIGHTS FROM THE

Extreme heat and agriculture report

Extreme heat is a powerful risk multiplier that has profound effects on agrifood systems globally and currently threatens the livelihoods of 1.23 billion people. Extreme heat damages crops, stresses livestock, depletes fisheries and increases the risk of wildfires. The impacts of extreme heat become much worse when combined with other hazards such as drought and are projected to get much worse as the world warms.

Agricultural communities are on the frontlines of the extreme heat crisis. Agricultural workers are 35 times more likely to die from occupational heat exposure than all workers combined in other sectors. In 2021, the latest year of statistics, 470 billion labour hours were lost globally due to extreme heat. This double blow of health risks and productivity loss disproportionately burdens rural women, who often face high exposure to heat and lack the resources to adapt.

The damage to production from extreme heat is pervasive across the agricultural sector. Yields of staple crops like maize and wheat are projected to decline by up to 10 percent for every 1°C of additional warming. By 2100, under a high emission scenario, nearly 50 percent of the world's cattle could be exposed to dangerous heat, with annual productivity losses nearing USD 40 billion in 2005 dollars. Many aquatic ecosystems face collapse, with nearly 8 in 10 commercial fish stocks projected to lose biomass. Fruit and nut trees and natural forests are also subject to production losses and are becoming increasingly vulnerable to catastrophic wildfires, which is a compounding factor with extreme heat.

Extreme heat is one of the most acute hazards facing agriculture. The true danger from extreme heat lies not only in direct losses but in its role in compounding existing vulnerabilities. With billions of livelihoods at stake, building resilience is no longer optional; it is imperative. Ultimately, there are limits to adaptation. The only lasting solution to the escalating threat of extreme heat lies in undertaking ambitious mitigation action to protect the future of global agrifood systems.

These highlights are drawn from the forthcoming joint FAO-WMO report. The full report explores the impact of extreme heat on agricultural producers and on crops, livestock, fisheries and aquaculture, and forests worldwide. Drawing on recent scientific evidence and country case studies, it highlights the independent and compound risks posed by extreme heat, underscores the urgency of mitigation, and presents pathways to strengthen resilience and sustainability across agricultural sectors.

FIGURE 1. **Impact pathways from extreme heat to agriculture**

Source: Authors' own elaboration

Legend

- Direct pathways from heat to outcomes
- Indirect pathways from heat to outcomes
- Meteorological phenomenon
- Outcomes

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IN PUNJAB, Pakistan, Increasingly severe heatwaves are devastating rural, rain-fed agricultural communities.

These events slash crop and fruit productivity by up to 50 percent and reduce livestock output. They create a dual crisis for households: diminished food production and lost income for food purchases. This severely limits household access to diverse, nutritious diets and disproportionately harms women, who face acute health risks from high heat exposure when carrying out agricultural labour. Systemic inequalities further restrict women's access to information and financial resources, compounding their vulnerability and forcing them to adopt coping strategies that compromise their own health and well-being.

Vulnerability of agriculture to extreme heat

The vulnerability of agriculture to extreme heat is systemic and rooted in the fundamental thermal limits of all living organisms. Every crop, animal, and aquatic species has a thermal safety margin – the gap between the temperatures it normally experiences and the threshold at which physiological damage occurs. Heat becomes 'extreme' when it surpasses these thresholds. For the majority of agricultural species these thresholds lie between 25–35°C during critical life stages, such as reproduction. Extreme heat also triggers widespread crises of direct physiological stress, depletes oxygen in water, fuels wildfires, alters the patterns of pests and the spread of disease, and forces fish to migrate. Critically, it also endangers agricultural workers, compromising the entire agricultural system's ability to function.

Observed impacts of extreme heat

The observational record clearly shows the vulnerability of agriculture to extreme heat has resulted in devastating losses. Case studies of individual heatwaves provide the starkest insights. For example, the 2014–2016 'blob' marine heatwave triggered a food chain collapse in the Pacific, leading to the starvation of millions of seabirds and the closure of major fisheries. Another marine heatwave in the Bering Sea led to the death of an estimated 10 billion snow crabs, 90 percent of the population, in 2018–19. On land, heat events have caused double-digit crop losses, suppressed forest productivity by up to 50 percent, and led to mass livestock mortality events involving hundreds of thousands of animals. These trends show no signs of abating and confirm that extreme heat is a systemic and damaging force impacting all agricultural subsectors.

Projected impacts of extreme heat

Future projections, using a range of climate scenarios and models, indicate that these trends will continue to worsen. For every 1°C of additional warming, yields of staple crops such as maize and wheat are projected to decline by 4 to 10 percent. Under a high-emission scenario, up to 75 percent of global livestock could be exposed to extreme heat stress by 2100, with annual production losses in the tens of billions of dollars. The impacts of marine heatwaves on fisheries are projected to be at least four times larger and faster than the effects of changes in mean temperatures. Forests face a dual threat of reduced growth and a dramatic increase in fire risk days. Projected damages are significantly lower under low-emission scenarios, underscoring the need for ambitious climate change mitigation to reduce future losses and safeguard the capacity of global agricultural systems to feed generations to come.

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BETWEEN 2022–2024, Morocco faced a devastating compound event in which a six-year drought was amplified by successive, intense heatwaves.

This dual challenge caused widespread agricultural collapse, with cereal yields plummeting by 43 percent to a historic low. The crisis triggered a cascade of compound outcomes: catastrophic wildfires burned a record amount of land, and heat-driven evaporation led to unprecedented water shortages in reservoirs, forcing widespread irrigation restrictions. This event exemplifies how the interaction of heat and drought can unleash simultaneous and interconnected crises across agriculture, water systems, and forests, and highlights the profound vulnerability of the entire region.

Compound events

The true danger of extreme heat often lies in its role as a risk multiplier in compound events. These events occur when multiple climate hazards overlap, producing impacts far greater than the sum of their parts. The most critical example is the heat-drought event, where a heatwave's high temperatures and solar radiation create a feedback loop that rapidly depletes soil moisture, triggering flash droughts and intensifying the build-up of more heat. This dual burden of heat and water stress is devastating for crops and livestock and greatly increases wildfire risks.

Compound outcomes

Beyond multiple hazards, a single extreme heat event can trigger a cascade of compound outcomes across the interconnected components of the agricultural system. Extreme heat affects crop yields, withers pastures for livestock, warms rivers to lethal levels for fish, and dries out forests, elevating wildfire risk. Critically, it also endangers the health and productivity of agricultural workers who must work under these conditions, compromising the ability of the entire agricultural system to respond to these simultaneous crises. This domino effect of overlapping hazards can overwhelm a farm or an entire region, demonstrating a systemic vulnerability that single-hazard analyses fail to capture.

Compound Outcomes of the 2023-2024 extreme heat event in Brazil

From late 2023 through 2024, Brazil was struck by a severe and prolonged extreme heat event, amplified by a strong El Niño and long-term climate change trends. Multiple record-breaking heatwaves swept across the country, with temperatures exceeding 5°C above the climatological mean. This intense heat directly affected the productivity of Brazil's primary crops. Daily maximum and even mean temperatures exceeded critical thresholds for soy on a record number of days. A critical finding is that, while meteorological drought was present, vegetation health indices confirmed that the widespread agricultural damage was primarily driven by direct heat stress rather than water scarcity. The relentless thermal pressure was a key driver of the nearly 10-percent reduction in the national soybean harvest from initial forecasts.

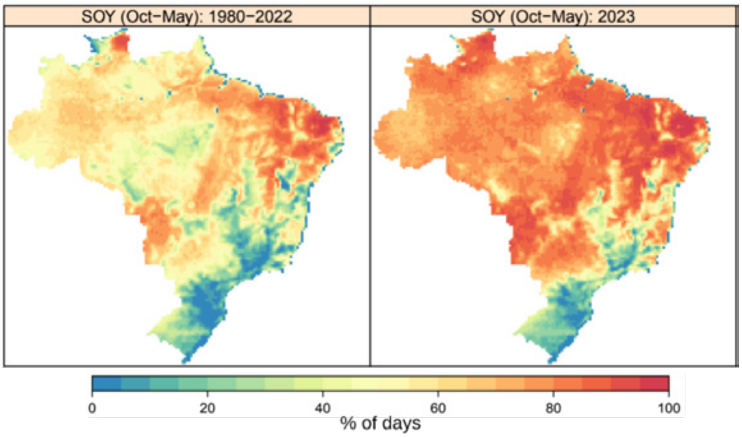

Figure 2. Percentage of days in which the maximum temperature exceeded the critical threshold of 30 °C during the growing season for soy (October to November). The left-hand map shows the average for the period 1980–2022, whereas the right-hand map shows October 2023 to May 2024.

Source: Authors' own elaboration

The heatwave triggered a cascade of devastating compound outcomes across the entire agricultural sector. The livestock industry faced severe pressure, with heat-sensitive animals such as swine enduring severe heat stress for 20 or more days per month in key regions. The dairy sector also saw significant impacts on animal health and productivity.

The extreme conditions also led to abnormally high fire weather risk and contributed to catastrophic wildfires. Simultaneously, the health and productivity of agricultural workers were compromised, as wet bulb globe temperatures – a measure of the heat stress that takes into account temperature, humidity, wind speed and solar radiation – exceeded safety thresholds on a record number of days in the North and Central-West regions, creating hazardous working conditions.

The event in Brazil also demonstrated how extreme heat can be linked to seemingly contradictory hazards. In April–May 2024, the heat dome blocked a weather front, causing unprecedented rainfall and catastrophic flooding in the southern state of Rio Grande do Sul. This flood devastated the nation's primary rice-producing region, destroyed unharvested soy, and displaced over 600 000 people. The 2023–2024 period in Brazil thus serves as a stark case study of how a primary extreme heat event can unleash a systemic crisis, simultaneously impacting crops, livestock, forests, fisheries, and human health through a series of interconnected compound events.

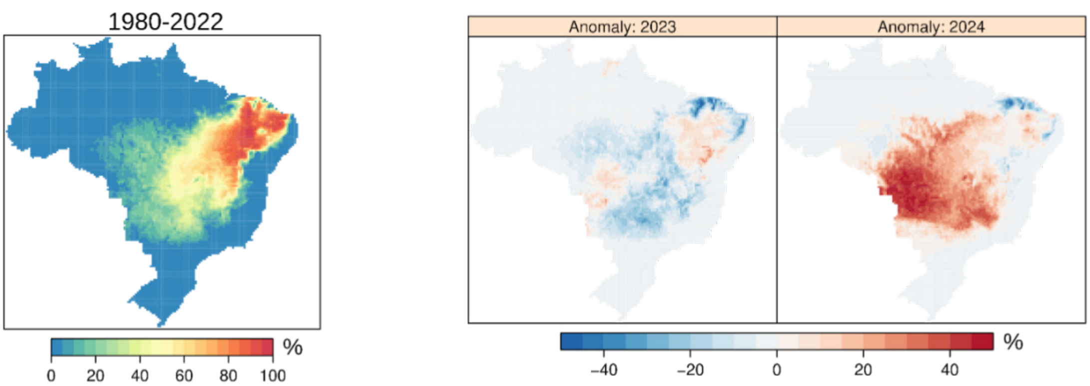

Figure 3. Percentage of days during the August-October fire season when the Fire Weather Index exceeded 30. The top row shows the climatological mean for 1980–2022; the bottom row shows differences (in percentage points) for 2023 and 2024 relative to that mean. Positive values indicate more days above the threshold than the climatological average; negative values indicate fewer.

Source: Authors' own elaboration

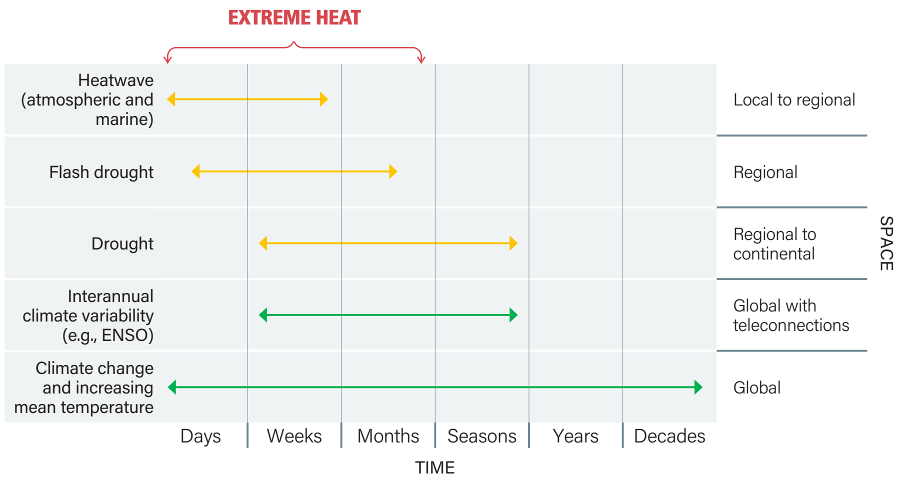

Figure 4. Extreme heat, underlying climate change and variability, and meteorological phenomena
Source: Authors own elaboration

Key Terms

Extreme heat refers to temperatures that surpass critical thresholds, causing significant physiological stress or physical harm to organisms. It can also trigger cascading effects on ecosystems, human health, and essential resources. Rather than being defined solely by temperature values, extreme heat is understood in terms of its context and impacts and is often associated with severe negative outcomes.

Heat stress denotes the impact(s) of excessive heat on a reference organism related to the species' tolerance. The threshold of heat-inducing stress typically changes across developmental stages. Individuals commonly show evidence of acclimation as temperatures rise.

Heatwaves are a prolonged period of abnormally hot weather, lasting from several days to weeks. Marine heatwaves are prolonged periods of unusually warm ocean water, at the surface or deeper, lasting days to months and often spanning large areas.

Drought is a slow-creeping phenomenon of prolonged precipitation deficiency. Extreme heat can intensify drought. In contrast, a flash drought is defined by its rapid onset over days or weeks and is often triggered directly by extreme heat.

IN SOUTHERN CHILE, sea surface temperatures rose by 2–4°C above average in 2016 and again in 2021, triggering massive algal blooms that caused hypoxia and toxicity. Over 40 000 tons of farmed salmon were lost, resulting in economic damages exceeding USD 800 million and widespread rural unemployment. This highlights the vulnerability of aquaculture systems to marine heatwaves, especially in high-density farming zones. It underscores the need for marine heat early warning systems, adaptive site selection, and ecosystem-based aquaculture management to enhance climate- and disaster-smart fisheries.

PORTUGAL'S CATASTROPHIC 2017 FIRE SEASON, driven by extreme heat, low humidity, and strong winds, burned a record 540 000 hectares and resulted in 116 fatalities.

The economic losses exceeded USD 1.2 billion, making it the nation's costliest natural disaster. The two most severe fire events occurred outside the official fire season, underscoring the trend toward longer fire seasons under climate change. This disaster underlines that while heat is not the sole driver of wildfire, it is a critical warning signal. Effective responses include using meteorological forecasts for early warnings, enhancing fire prevention, and implementing targeted fuel management.

Mitigation

While this report focuses on adaptation, the ultimate solution to the challenge of extreme heat lies in ambitious climate change mitigation. The impacts of extreme heat on agriculture create a dangerous feedback loop: heat-induced productivity losses and agricultural expansion increase land-use change emissions. Furthermore, extreme heat can turn natural carbon sinks such as forests into net carbon sources, as can be seen from the increasing emissions from wildfires. This cycle, where the impacts of warming drive further emissions and thus more warming, underscores the reality that adaptation has hard limits. Without a decisive global effort to reduce greenhouse gas emissions, the agricultural sector will face challenges that no amount of adaptation can overcome, threatening the viability of the entire global food system.

Adaptation and risk governance

Building resilience to extreme heat requires effective adaptation that is multi-faceted and combines technical options, such as developing heat-tolerant breeds and implementing sustainable irrigation, with knowledge-based management. A key opportunity lies in leveraging the predictability of heat through anticipatory actions and agrometeorological advisories linked to early warning systems. This would mark a shift from reactive crisis management to proactive risk reduction. However, successful adaptation is hindered by financial, institutional, and policy barriers. Overcoming these barriers requires a transformative approach to risk governance that integrates extreme heat planning across all sectors and levels of government. This involves establishing clear institutional mandates, fostering interdisciplinary collaboration, and ensuring that national heat action plans directly support agricultural resilience, particularly for the most vulnerable small-scale agricultural producers.

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ACROSS AFRICA, the number of agricultural workers labouring under dangerous heat is set to skyrocket in the coming decades.

By mid-century, exposure to extreme heat stress during the main growing season is projected to increase by 78 percent in West Africa; 83 percent in East Southern Africa; and more than 100 percent in Central Africa. This surge is driven primarily by accelerating climate change, with population growth playing only a minor role, and poses a severe threat to the health and productivity of millions of farmers.

Conclusion

Extreme heat is one of the central, interconnected drivers of the climate crisis in agriculture. It threatens global food security and the livelihoods of billions. More than an independent hazard, it acts as a powerful risk multiplier, amplifying drought and triggering wildfires, leading to compound negative outcomes for crops, livestock, fisheries and aquaculture, and forests. These impacts directly endanger the health and productivity of agricultural workers, who are on the frontlines of this crisis. Effective adaptation opportunities exist, particularly through the use of predictable heat forecasts to enable effective risk management. However, these actions must be supported by interdisciplinary research and integrated risk governance. Building resilience is imperative, but ultimately there are profound limits to adaptation.

The only lasting solution to the escalating threat of extreme heat lies in ambitious climate change mitigation to protect the future of global agrifood systems.