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Climate Change and Food Security: A Minimal-Impact Perspective

Climate and Weather are Marginal beside Technology, Trade and Adaptation

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Abstract

Global food production has risen strongly throughout the period of modern warming. No negative climate signal is visible in the aggregate trends for cereal, meat or aquatic-food output. This paper argues that climate and weather effects on global food production - positive as well as negative - are marginal compared with population and income growth, technology, trade, institutions and farmers' adaptation. Claims that anthropogenic warming has already materially reduced global production are counterfactual estimates: they compare observed output with modelled output in an unobservable world without warming. Such studies may estimate an opportunity loss, but they do not demonstrate an observed decline in food production. Many impact assessments also represent adaptation inadequately by holding crop choice, sowing dates, cultivars, irrigation, production location, trade or technological progress too rigidly. The empirical record instead shows record production, rising yields and slight contraction of total agricultural land since 2001. Hunger persists mainly where poverty, conflict, inflation and weak governance restrict access to food. The practical conclusion is clear: affordable energy and fertilizer, open trade, innovation and good governance are the foundations of food security. Unless governments create artificial scarcity through destructive policies, the world can supply the quantity and quality of food people demand with a steadily declining environmental footprint.

Keywords: food security; agricultural productivity; climate adaptation; trade; aquaculture; decoupling; energy policy

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1. Introduction

The presentation at IKEK-17 asked a deliberately simple question: how large is the impact of climate change on food security compared with the other forces shaping the food system? The answer advanced here is: marginal in relative terms, for both negative and positive effects. Weather matters greatly to an individual farmer in a particular season, but global food security is not identical to a local harvest. It is an economic and institutional outcome governed mainly by productivity, income, storage, transport, trade, processing and the ability to adapt.

The distinction between a weather effect and a food-security crisis is essential. A drought can reduce one harvest, yet a wealthy, connected society can import food, change suppliers and absorb the loss. The same shock in a poor or conflict-ridden country can become a humanitarian disaster. The decisive variables are therefore resilience, wealth, trade and governance. Climate and weather are background conditions within that system, not sufficient explanations of hunger.

2. The empirical baseline: more food from each hectare

The long-run record is one of expansion and intensification. FAO reports that global cereal production reached 3.1 billion tonnes in 2024, 27 percent above 2010, mainly because yields improved [2]. Over 2001-2023, total agricultural land contracted by about 2 percent even as cropland expanded; agricultural value produced per hectare rose by more than 60 percent [3]. This is the central decoupling result: more output does not require proportionally more land.

The same pattern is visible in animal production and in the sea. Global fisheries and aquaculture produced 195 million tonnes of aquatic animals in 2024. Aquaculture supplied 103 million tonnes, or 53 percent, and has generated nearly all growth in aquatic animal production since the late 1980s [5]. This transition from hunting wild stocks to farming aquatic animals is comparable to the much earlier transition from hunting terrestrial animals to livestock farming.

The record does not imply that food insecurity has disappeared. In 2024 an estimated 673 million people, 8.2 percent of the world population, experienced hunger [4]. However, the coexistence of record output with persistent hunger points mainly to failures of access: poverty, conflict, high food-price inflation, poor infrastructure and governance. Global scarcity is not the same thing as local deprivation.

Table 1: Selected indicators of the global food system.

Indicator	Latest level	Recent/long-run signal	Source
World population	8.2 billion (2024)	Projected peak near 10.3 billion in the mid-2080s	[1]
Cereal production	3.1 Gt (2024)	+27% since 2010, mainly yield gains	[2]
Agricultural land	4.8 billion ha (2023)	-2% since 2001; output value per ha increased >60%	[3]
People facing hunger	673 million; 8.2% (2024)	Down from 2022, but severe regional divergence	[4]
Aquatic animal production	195 Mt (2024)	Aquaculture 103 Mt and 53% of total	[5]

Note: Figures are rounded. The indicators show the scale of output, access and land-use trends; they do not by themselves identify causal effects of climate change.

3. Demand, technology and trade are the main drivers

Demand grows with population and prosperity. The United Nations estimates a world population of 8.2 billion in 2024 and projects a peak of about 10.3 billion in the mid-2080s [1]. As incomes rise, consumers demand more varied and higher-value diets, including meat, dairy, fruit and aquatic foods. This demand is not a problem to be suppressed; it is a sign that people are escaping poverty.

Supply has repeatedly responded through knowledge and capital: plant and animal breeding, mineral fertilizer, mechanization, irrigation, crop protection, refrigeration, logistics, precision agriculture and increasingly gene editing. These technologies raise output per unit of land, labour, water and feed. They also reduce vulnerability because farmers can change varieties, planting dates, inputs and production locations.

Trade is another form of adaptation. Local production shocks are inevitable, but they need not become local famine when food can move from surplus to deficit regions. FAO reports that the value of food and agricultural trade increased fivefold between 2000 and 2024 [6]. Resilient supply chains require diversified suppliers, functioning ports and storage, and predictable trade rules. Export bans and protectionism often amplify a shock that markets could otherwise distribute.

4. Climate and weather: marginal in the global record

Global food production has continued to rise during nearly 1.5 degrees C of warming. No climate penalty can be read directly from the aggregate production series. The IPCC and several statistical

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studies nevertheless attribute part of the difference between observed output and a modelled no-warming counterfactual to climate change [7-9]. That is not an observed fall in food production; it is an estimated opportunity loss relative to an unknowable alternative history. The distinction matters. The measured real-world result is rapidly rising output, not climate-driven decline.

Adaptation is also commonly underrepresented. Farmers do not remain fixed while climate changes: they alter sowing dates, cultivars, crops, irrigation, inputs, production methods and sometimes location. Markets redirect trade, researchers develop new varieties, and infrastructure changes the vulnerability of the entire system. Studies that include only a narrow selection of these responses will tend to overstate damage. Even within existing models, timely adjustment of growing periods and cultivars materially improves projected yields [11], while empirical work that attempts to include producer adaptation substantially reduces estimated future calorie losses [10]. These studies still cannot capture innovations that have not yet been invented or commercialized.

The same caution applies to claimed positive climate effects. Higher atmospheric CO₂ can stimulate photosynthesis and water-use efficiency, especially in C₃ crops, while elevated temperature can help some regions and harm others. Nutrient dilution and heat stress may offset part of the benefit [10, 12]. At the scale of the global food system, however, both the positive and negative effects remain secondary to breeding, fertilizer, mechanization, crop protection, irrigation, logistics, trade and aquaculture.

5. Policy: Do not manufacture food insecurity

The most robust food-security strategy is to preserve abundance and adaptive capacity. Priorities include affordable and reliable energy, fertilizer, agricultural research, modern breeding and gene editing, irrigation and water management, precision application of inputs, improved storage, diversified trade and sustainable expansion of aquaculture. Controlled-environment agriculture and other energy-intensive systems can add further resilience where dependable low-cost electricity is available.

Environmental policy should be judged per unit of nutritious food, not by romantic labels. Organic systems yields are much lower than conventional yields, with gaps strongly dependent on crop and management [13]. A blanket conversion therefore risks increasing land demand. Likewise, food-crop biofuel mandates can divert land and grain from food markets and induce land-use change [14].

The largest avoidable threats are political: war, corruption, trade restrictions, hostility to productive technologies, and policies that make energy, fertilizer, transport, livestock or land unnecessarily expensive. A very costly green transition that weakens reliable energy systems and suppresses agricultural productivity can make society less robust to drought, conflict, crop disease and every other shock. Climate policy should therefore pass a simple test: does it strengthen or weaken the food system's capacity to adapt?

6. Conclusion

Climate and weather affect individual harvests, but their net influence on global food production is marginal compared with productivity, technology, trade and adaptation. The aggregate record contains no visible climate-driven decline: the world produces more cereal, meat and aquatic food, from less land per person, while aquaculture opens a vast additional production domain.

Hunger persists where people cannot command food, not because humanity has exhausted its biological capacity to produce it. Nothing in the production record indicates a serious risk that the world will be unable to provide all the food people can eat, in the quality they increasingly demand. The real danger is self-inflicted scarcity. Unless politicians undermine reliable energy,

fertilizer, trade, technology and economic growth through foolish and excessively costly policies, global food supply will continue to expand while its footprint per unit of food declines.

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