Climate Change Food Bowl

The Future of Food

SEPTEMBER 2023 | PART 1

Gallagher

Insights

1. **Climate variability and unpredictability, geopolitical conflict, food price inflation and growing food insecurity** are driving the need for structural change to respond to the climate change challenge and provide increased food supply chain resilience.

2. **2023 research published by Nature Climate Change**[1], treated each greenhouse gas separately for 94 key types of food, enabling their impact on climate over time to be better understood. Feeding this emissions data into a climate change simulation model showed that the continuation of today's food production would lead to a temperature rise of 0.7°C by 2100 if global population growth was low, and a 0.9°C rise if population growth was high.

3. **Global food insecurity and nutrition—**2022 forecasts remain significantly above pre-COVID-19 pandemic levels[2], according to 2023 reporting by the Food and Agriculture Organization of the United Nations.

4. **2023 El Niño related climate patterns** highlight the fragility of the major global food bowls, with rice export bans and India and major rice crop producers such as Thailand and Vietnam experiencing crop failure and reduced yields, leading to price increases and price caps in markets such as the Philippines to protect lower income groups from food insecurity.

Overview

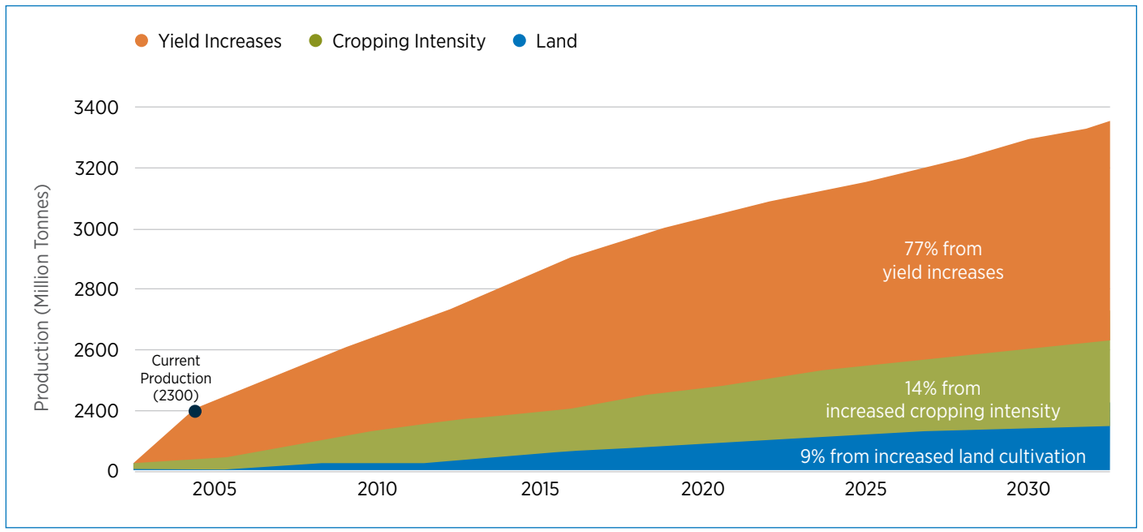
Unprecedented shifts in climate change patterns and a complex mix of ecological and environmental challenges have raised concerns of global food bowl security. The disruption of traditional agricultural practices and emergence of extreme weather events pose a significant threat, and call for coordinated action to deliver a sustainable and resilient future for food production.

This Spotlight report examines the intersection of climate change and food systems while exploring:

- Connected risks for the agricultural sector and global economy as climate change impact accelerates.
- Climate change resistant crops as a sustainable food source, globally.
- Crop diversification as a contributor to a resilient food supply.

The food production sector is equipped to directly respond to climate change impact through increased resilience and accessibility of food, at local and international levels. There's a circular flow of connected risks to consider, from rebalancing food production impact on climate change outcomes versus diversifying crop types and introducing new variants that are able to adapt to unpredictable weather patterns and the evolving needs of the consumers.

Global crop yield growth required to supply a forecasted 35% risk in global food demand by 2030



Source: Farming First

Spotlight

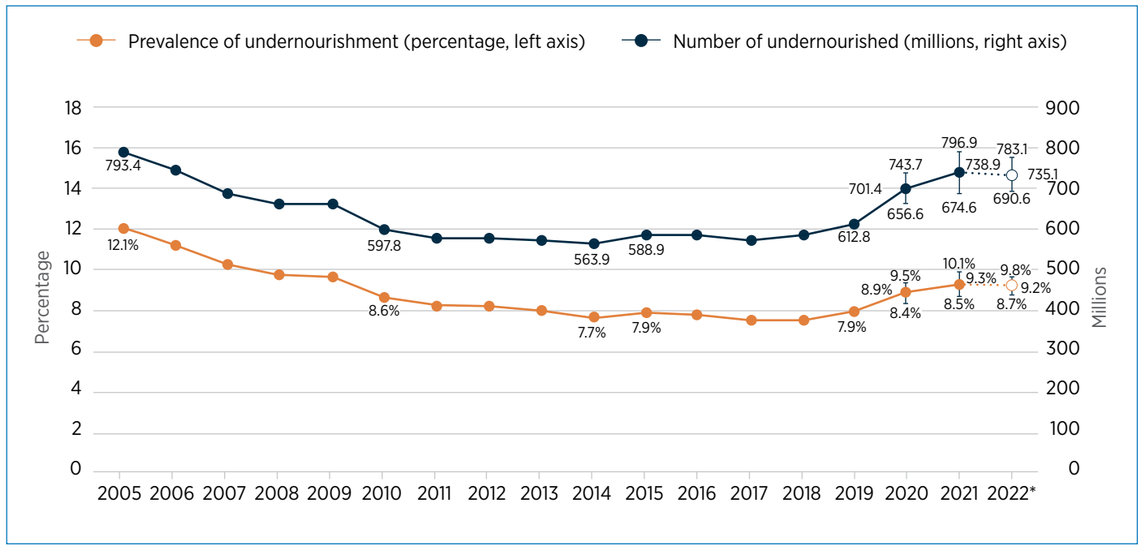
Four trends are driving the impetus for structural changes to global food production:

1. **Climate variability and unpredictability**: Creating increased planning challenges for farmers and supply chain. Risk can be insured, uncertainty is more challenging.
2. **Geopolitical conflict**: Disrupting the flow of food, increasing cost, reducing supply of critical crops versus growing demand. The Russia/Ukraine war has directly impacted roughly 30% of the world's cereal crop output fueling pricing inflation and supply restrictions, and shifting trade flow tensions are further challenging the global food supply chain.
3. **Food inflation**: Reflecting the above two points. Supply, demand along with inflation and rising transportation and production costs.
4. **Food insecurity**: With more than 150 million of the global population undernourished,[3] sustainable, climate change resilient crops and food supply are a pressing need and driver of change.

Connected risk landscape

Aside from household consumption, the global supply chain of food supports diverse industries from field to consumer. Hospitality & tourism, FMCG sector operators, farming and agribusiness, construction, manufacturing through to agrichemicals (including fertilizers) and seed/feed suppliers. Imbalances and disruption in the global food supply has connected risk exposure, and contributes to a US$9.4tn global market in 2023, expected to grow annually by 6.74% (CAGR 2023-2028). With the food sector contributing 30% of global emissions and current global food consumption patterns potentially adding 1°C to warming by 2100, improvements to production practices, transition to healthier dietary choices and reductions in food waste are needed now to mitigate a range of risks challenging global food security.

Global food insecurity – 2022 forecasts remain significantly above pre-COVID-19 pandemic levels[4]



Source: The State of Food Security and Nutrition in the World 2023 (fao.org)

Climate change impact on the global food bowl

Climate change poses significant challenges and risks for the agricultural sector and the global economy, resulting in inflated food prices, food shortages and increased vulnerability to extreme weather events while driving inflation[5] and accelerating the global food crisis. Diversification and the introduction of higher yield, climate change resilient crop varieties have become a critical priority in recent years.

Climate pattern variability has made it increasingly difficult for agricultural sector operators to make decisions. The increased sophistication and application of data such as with parametric insurance[6] products is providing a layer of financial protection for crops and risks that were historically uninsurable, and ensuring the food chain is adequately protected. Rising temperatures, altered precipitation patterns, the increased frequency of extreme weather events and changing pest and plant disease dynamics all pose significant challenges for food bowl producers.

Elevated levels of carbon dioxide (CO2) can impact crop yields.[7] While some laboratory experiments suggest that higher CO2 levels can actually promote plant growth, it is important to consider other factors that may counteract these potential increases. Changes in temperatures, ozone levels, water availability and soil nutrient depletion will more than offset any net positive impact.

The changes in climatic variables that affect crop production are expected to have significant implications both regionally and globally in terms of food production. To assess the likely impacts of climate change on crop yield, researchers rely on experimental data or crop growth simulation models such as DSSAT (Decision Support System for Agrotechnology Transfer) a software platform that can simulate growth patterns for more than 42 crops.[8] Crop growth simulation models can be used as decision support systems to assess the risk and economic impacts of management strategies in agriculture.

Defining "food bowl"

The term "food bowl" typically refers to a region or area known for its high agricultural productivity and significant contribution to food production. It is often used to describe a geographic area that serves as a primary source of food for a nation or a significant portion of the population. Some of the world's top food bowls are China, India, the US, Brazil, Indonesia, and Turkey.

Crop growth simulation models

Simulation model	Crop	Predicted impacts
CERES-Maize	Maize	Dry matter
		Sustainable production
		Planting date and different weather
		Precise and deficit irrigation
CERES-Wheat	Wheat	CO2 levels
CropSyst	Wheat	Rainfall and warming temperature
CERES-Rice	Rice	CO2 levels
SWAP	Rice	CO2 levels
InFoCrop	Rice	Elevated CO2 and temperature
	Rice and wheat	Climate change
IBSNAT-ICASA	Cereal/Soybean	Climate change
GLAM	Peanut	Climate uncertainty
GLYCIM	Soybean	Temperature, rainfall and CO2 concentration
SWAT	Maize	Climate vulnerability

Risk landscape

The risks associated with climate change impacts on food bowl regions extend beyond crop production:

- **Livestock farming.** Meat and dairy plays a significant role in servicing the global food supply and is as vulnerable as arable crops to climate change effects.
- **Heat stress and loss of natural food sources can reduce animal productivity** and impair livestock health, leading to economic losses for farmers.
- **Reduced availability/higher cost of livestock feed**, which can have ripple effects throughout the livestock industry, potentially affecting animal health and overall agricultural sustainability.
- Reduced food production can lead to **increased food prices, food scarcity, and potential food crises**, impacting vulnerable populations and exacerbating global food inequality.
- Economic implications including **decreased agricultural revenues, loss of jobs, and diminished trade opportunities**, affecting local economies and global markets.

Research published by Nature Climate Change,[9] treated each greenhouse gas separately for 94 key types of food, enabling their impact on climate over time to be better understood. Feeding this emissions data into a climate change simulation model showed that the continuation of today's food production would lead to a rise of 0.7°C by 2100 if global population growth was low and a 0.9°C rise if population growth was high.

Addressing these risks posed by climate change requires comprehensive strategies that encompass adaptation and mitigation measures. It is crucial to invest in research and development to develop climate-resilient crops, improve irrigation techniques and promote sustainable farming practices. Enhancing water management, implementing efficient resource utilization and diversifying agricultural systems are all vital steps to ensuring the resilience of food bowl regions in the face of climate change, safeguarding food security and supporting the global economy.

Dietary patterns and climate change

Dietary preferences and food consumption patterns have a significant impact on climate change due to the emissions associated with food production, particularly in the agricultural sector. Here are some ways in which changes in dietary patterns can contribute to climate change mitigation:

- **Reducing meat consumption:** Commercial meat production, particularly beef and lamb, creates a substantial carbon footprint. Livestock farming requires substantial amounts of land, water and feed and produces significant greenhouse gas emissions, including methane from enteric fermentation and nitrous oxide from manure management. Shifting towards plant-based diets and/or reducing meat consumption could help lower emissions.
- **Switching to plant-based protein sources:** Legumes (beans, lentils, and peas), nuts, and seeds, have a lower environmental impact compared to animal-based protein sources, requiring fewer resources and reducing greenhouse gas emissions during production.
- **Opting for locally sourced and seasonal foods:** Choosing locally sourced and seasonal foods can reduce the energy and emissions associated with transportation, refrigeration, and storage. By supporting local farmers, consumers contribute to a more sustainable and resilient food system and support local economies.
- **Minimizing food waste:** Reducing household food waste through improved meal planning, proper storage and conscious consumption, helps to reduce the resources expended in food production and lowers emissions from decomposing waste deposited in landfills.
- **Supporting sustainable agriculture:** Organic farming, agroforestry, and regenerative agriculture promote soil health, reduce the use of synthetic inputs, sequester carbon, and enhance overall ecosystem resilience.
- **Considering the carbon footprint of food:** Being aware of the carbon footprint of different food choices can help guide decisions towards lower-emission options. For example, certain fruits and vegetables may have a higher carbon footprint when grown in energy-intensive systems such as heated greenhouses or when transported over long distances.

In 2019, a group of 37 leading food and climate scientists came together as the EAT-Lancet Commission to analyze how different transforming eating habits, improving food production and reducing food waste would reduce food bowl insecurity. The study presented a range of findings and identified food as a defining issue of the 21st century.

Delivering a sustainable food supply requires systemic changes to dietary intake and a rebalancing of the food plate, with 50% consisting of fruit and vegetables and a reduced proportion of animal sources of protein.

Source: The “planetary health diet”. Credit: The EAT-Lancet Commission (2019).

Building a climate resilient food bowl

New, genetically modified organisms (GMOs), by introducing resilient crop and food sources, offer significant potential as a climate change resilient solution. Crop varieties are specifically designed or genetically modified to withstand adverse climate impact, such as increased temperatures, droughts, floods and pests, and encourage greater yields with connected efficiency improvements.

Based on 2019 research data from the International Service for the Acquisition of Agri-biotech Applications (ISAAA), more than 18 million farmers in 29 countries, including 19 developing nations, planted over 190 million hectares (469.5 million acres) of GMO crops in 2019.[11] This represents a 5.7 percent increase over 2015, and the highest area of biotech crop adoption since cultivation began in 1996.

By 2017, GMO crops were being cultivated in 24 countries globally. The approval procedures for GMO crops differs between countries, internationally; however, all regulations share the common goal of ensuring the safety of GMOs for human and animal health, as well as the environment.

What is GMO?

GMO, or Genetically Modified Organisms, refers to the alteration of the genetic material (DNA) of a plant, animal or microorganism using technology to make precise modifications to the DNA, including the transfer of specific genetic material from one organism to another.

Spotlight

Examples of GMO foods include:

- **Cultured meat.** Laboratory grown meat is produced by isolating muscle cells and living tissue from animals and nurturing in a laboratory controlled environment to mitigate the risk of food-borne pathogens and disease. Cultured meat has historically been viewed as more sustainable and environmentally friendly compared to traditionally farmed meat. According to the Food and Agriculture Organization of the United Nations (FAO),[12] the livestock industry contributes an estimated 7.1 GT of CO2, accounting for 14.5% of global greenhouse gas emissions.[13]
- **Plant-based meat.** Cholesterol-free, nutrient-rich, high in fiber, and lower in calories, plant-based meat production reduces greenhouse gas emissions by up to 90% versus traditional livestock meat production methods. Fueled by the increasing demand for healthier meat alternatives, the plant-based meat market is experiencing rapid growth. Currently valued at $20 billion, this industry is projected to become an $85 billion market by 2030, according to analysts at Swiss multinational bank, UBS Group AG.[16] "Overall, we estimate the food innovation opportunity represents a $700 billion market by 2030," said UBS.[17] Though the market could surpass this estimate "if plant-based meat adoption accelerates thanks to innovation and increasing consumer awareness."
- **Legumes.** Beans (legumes) are viewed as a "food of the future" due to their versatility and affordability. Thriving in diverse settings ranging from coastal regions to mountainous slopes, legumes are able to adapt to climate change patterns and have 20,000 known varietals.
- **Wild cereals.** Cereals, with more than 10,000 plant species, presents a wealth of possibilities for the development of innovative food options. Fonio (Digitaria exilis),[18] primarily grown in West Africa is widely utilized in the preparation of couscous, porridge and beverages. Locally cultivated as a staple crop, fonio demonstrates impressive resilience, thriving even in arid conditions. Its ability to tolerate dry environments makes it a valuable and sustainable food source in regions affected by water scarcity.
- **False banana (Enset).** Enset, commonly known as the "false banana," shares a close relationship with the banana plant, Consumption is currently limited to a specific region in Ethiopia. While the fruit of the enset is inedible, the starchy stems and roots can be fermented and used to make porridge and bread. 2022 research undertaken by Hawassa University, Awassa, Ethiopia and the Royal Botanic Gardens, London (UK), suggest that the false banana has the potential to feed over 100 million people in the future, and boost food security to rebalance crop yields affected by climate change.[19]

Ongoing research provides a shifting perspective. Although a 2011 study by Oxford University and the University of Amsterdam[14] found that cultured meat had the potential to reduce greenhouse gas emissions by up to 96%, subsequent research by the Oxford University revealed in 2019 that, "cultured meat production requiring large energy inputs could increase global warming more than some types of cattle farming if energy systems remain dependent on fossil fuels. Currently proposed types of lab-grown meat cannot provide a cure-all for the detrimental climate impacts of meat production without a large-scale transition to a decarbonized energy system, a new study has found."[15]

What does GMO bring to the table?

The development and adoption of climate-resilient crops creates new economic opportunities. Researchers, breeders and seed companies involved in the development of these crops contribute to technological advancements in agriculture. Farmers who adopt these resilient crops can potentially increase their profitability by producing higher yields and accessing niche markets focused on climate-friendly and sustainable products.

Some crop varietals have the ability to capture and store more carbon dioxide in their biomass or within the soil, thus acting as natural carbon sinks. Additionally, sustainable agricultural practices associated with the cultivation of these crops, such as reduced tillage and optimized fertilizer use, can help mitigate greenhouse gas emissions and promote soil health.

The emergence of climate change resilient growth crops presents a transformative opportunity for agriculture. By harnessing the power of science and innovation, these crops offer a way to adapt to the challenges of a changing climate while ensuring food security, environmental sustainability, and economic prosperity for communities worldwide.

Also, moving away from monoculture farming practices can help mitigate the impact of plant pandemics. By adopting diverse cropping systems, farmers can create more resilient and sustainable agricultural landscapes, reducing the vulnerability to plant pandemics.

Downside risk includes allergic reactions (where genetic modification triggers an allergen), antibacterial resistance, cancer, resistance to herbicides and species crossing that introduces allergens such as nuts into the food chain. While reporting varies and there is no concrete scientific evidence to support GMO crops being a harmful addition to the food bowl, concerns continue to be raised and are being taking into consideration by policymakers, scientists and food research technicians.

While GMO foods are banned in a long list of countries globally, perspectives have shifted in others such as the UK[20] that has seen the laws relaxed for gene-edited food production, however, the scope of the change is restricted to only allow genetic changes that could also have been produced naturally or through traditional crossbreeding programs already in use today.

Closing remarks

Growing food insecurity and the 2023 impact of El Niño[21] disrupting the major rice bowls in India and China highlight the pressing need for action and investment in critical research to stabilize food production. These efforts can be supported by government and NGO-led initiatives by offering subsidies to farmers who are diversifying, investing in new varieties and/or considering changes in land use.

Ultimately, while there is no quick fix to climate change or food crop sustainability, GMO crops and shifts in agricultural practices are helping farmers to adapt and evolve. With the emergence of laboratory engineered crops varietals presenting better yields and climate pattern resilient, there is room for optimism that the food bowl could be rebalanced to reduce food insecurity while tacking the carbon footprint of agricultural sector production.

Climate Change Food Bowl: Part 2 will explore risk scenarios and the potential impact on economic GDP, food supply chain resilience and the cross-industry risk landscape.

Citations

1 Ivanovich, C.C., Sun, T., Gordon, D.R. *et al.* "Future warming from global food consumption," *Nature Climate Change*, March 3, 2023.
2 "The State of Food Security and Nutrition in the World 2023," *Food and Agriculture Organization of the United Nations*, 2023.
3 Ritchie, Hannah, Rosado, Pablo, Roser, Max. "Hunger and Undernourishment," *Our World in Data,* 2023.
4 "The State of Food Security and Nutrition in the World 2023," *Food and Agriculture Organization of the United Nations,* 2023.
5 "Climate change is accelerating the global food crisis..." *World Economic Forum,* July 11, 2023.
6 Nigudkar, Supriya. "Parametric Insurance: An Important Tool for Climate Change Adaptation," *Farming First,* December 10, 2021.
7 "Rising Carbon Dioxide Levels Will Help and Hurt Crops," *NASA*, May 3, 2016.
8 DSSAT Overview - DSSAT.net
9 Ivanovich, C.C., Sun, T., Gordon, D.R. *et al.* "Future warming from global food consumption," *Nature Climate Change*, March 3, 2023.
10 Dunne, Daisy. "Interactive: What is the climate impact of eating meat and dairy?" *Carbon Brief,* September 14, 2020.
11 "Where are GMO crops and animals approved and banned?" *Genetic Literacy Project.*
12 "FAO: News Article: Key facts and findings," *Food and Agriculture Organization of the United Nations.*
13 "Moving Towards Sustainability: The Livestock Sector and the World Bank," *The World Bank,* October 18, 2021.
14 "Lab-grown meat would 'cut emissions and save energy'," *University of Oxford,* June 21, 2011.
15 "Is lab-grown meat really better for the environment?" *University of Oxford,* February 19, 2019.
16 Pritchett, Liam. "The Global Vegan Meat Market Value Projected at $85 Billion," *LiveKindly.*
17 "The future of food," *UBS.*
18 Burton, George, Gori, Bendetta, Camara, Saidou *et al.* "A journey to discover fonio: West Africa's "forgotten crop," *Kew,* January 31, 2023.
19 Briggs, Helen. "False banana: Is Ethiopia's enset 'wondercrop' for climate change?" *BBC News,* January 21, 2022.
20 Ghosh, Pallab. "Commercial development of gene-edited food now legal in England." *BBC News,* March 23, 2023.
21 Ratcliffe, Rebecca, Siradapuvadol, Navaon. "'Major disruptor': El Niño threatens the world's rice supplies," *The Guardian.* September 6, 2023.

AJG.com **The Gallagher Way.** Since 1927.