

# *What do we know about* **THE FUTURE OF MAIZE VALUE CHAINS IN A CHANGING CLIMATE AND AGRIFOOD SYSTEM?**

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## *Key messages*

- Population growth, changing diets, and a rapidly growing feed sector are contributing to a sharp increase in global maize demand, which is expected to double by 2050 relative to 2010.
- Average global maize yield is projected to decrease by 11 percent under a global warming scenario of 2°C (2060–2084) relative to the 1986–2005 period (in the absence of technological change, adaptation, or market adjustments).
- The feed demand for maize is expected to grow faster in the coming few decades, largely driven by rapid economic growth and diet shifts in highly populated regions in Asia, the Middle East, and Latin America.
- Meeting the growing demand for maize will require dramatic increases in production, marketing, use, and resilience of maize-based farming systems.
- While the supply of maize over the coming decades will be constrained by climate change and limited availability of land and water, technological and policy innovations will bring new opportunities.
- The combined challenges of increasing food demand, persistent poverty and malnutrition, natural resource depletion, and climate change will require the world to double the productivity and boost the sustainability and resilience of maize-based farming systems within planetary boundaries.

## RECENT TRENDS AND CHALLENGES

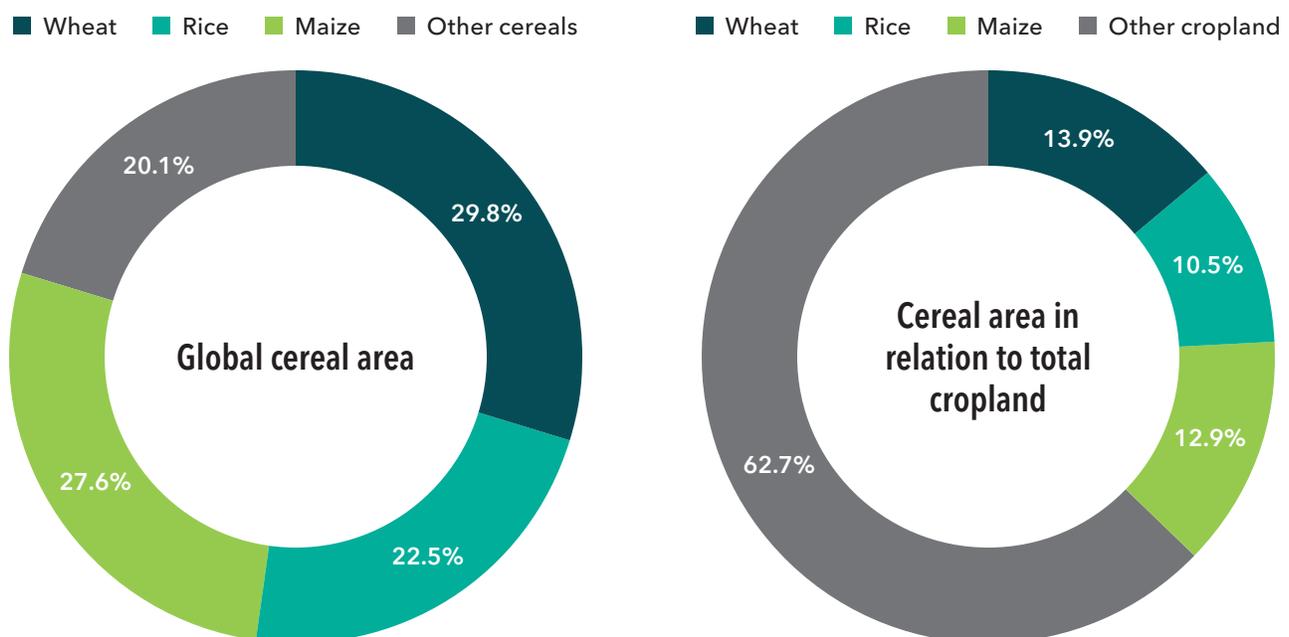
Maize is the world's most multipurpose crop and continues to be the leading global cereal in terms of production (more than 1.2 billion metric tons a year), area coverage (more than 202 million hectares), and utilization (food, feed, and industrial input) (Erenstein et al. 2022; FAO 2024). Maize is produced across temperate and tropical zones on all continents, representing 27.6 percent of the global cereal area, and is grown on 12.9 percent of the total cropland available (Figure 1) (FAO 2024). Maize value chains are influenced by various global, regional, national, and subnational drivers, among which the following are the most significant.

**Rising incomes, growing urban population, and dietary changes.** Rising income levels and urbanization – especially in densely populated developing countries where dietary preferences are diversifying – are driving up demand for maize significantly in both the food and feed sectors (Grote et al. 2021). This surge in demand competes with alternative uses such as industrial and bio-fuel applications. Due to the strong demand for livestock feed – driven mainly by dietary shifts to animal products,

and particularly noticeable in Asia – global demand for maize is expected to outpace that for other major cereals (Erenstein et al. 2022).

**Declining land and water resources and a growing need for intensification.** Area expansion has been one of the means to increase maize production, particularly in the developing world (Cairns et al. 2021). Thus, a decline in the availability of land and water resources due to land degradation and mismanagement and constraints to expansion to new areas will negatively affect maize value chains. Land availability for future maize expansion is limited in many parts of the world, although there is perceived land availability in Africa and East Asia. Even if new land is available, conversion to cropland will generate environmental costs in terms of increased land degradation, CO<sub>2</sub> emissions, and biodiversity loss (van Ittersum et al. 2016). Globally, most freshwater is withdrawn by agriculture, reaching up to 90 percent of the total freshwater use in fast-growing economies. Increasing global water scarcity is limiting the prospects of developing irrigation systems in many parts of the world's agricultural lands (Grote et al. 2021). Given increasing temperatures and low water management capacities, future maize production is most likely to be affected by water scarcity in Africa and South Asia. On the other hand, intensification

**FIGURE 1** Shares of cereals globally and relative to total cereal area and total cropland, 2020–2022 average



Source: FAOSTAT.

of maize production is expected to free existing marginal land and reduce pressure on natural ecosystems from agricultural conversion (Stevenson et al. 2013). Sustainable intensification has been found to increase maize yields in rainfed and irrigated systems and will likely be the future means to bolster both the maize supply and the nutritional diversity of maize-based farming systems (Grote et al. 2021).

**Climate variability and change.** Climate change is expected to strongly affect the supply, price, and nutritional quality of maize due to increasing temperatures, frequent extreme weather events (for example, droughts and floods), changing agroecological conditions (for example, crop seasons), and shrinking suitable cultivated areas (Thornton et al. 2014; Grote et al. 2021; Gbegbelegbe et al. 2024). Moreover, climate change reduces maize production by increasing the incidence and severity of existing and emerging diseases and insect pests (Elad and Pertot 2014; Cairns and Prasanna 2018; Deutsch et al. 2018). The recent emergence of maize lethal necrosis disease (Sileshi and Gebeyehu 2021) and the fall armyworm (De Groote et al. 2020) in African maize systems and the havoc and damage these caused in the region are poignant examples of the potential consequences of climate change. In many areas of sub-Saharan Africa and the Indo-Gangetic Plains, climate variability accounts for over 50 percent of the total variation in maize yields (Ray et al. 2015). The negative impact of climate change and variability on maize yields in major exporting countries is expected to further destabilize global grain trade and international grain prices, affecting close to 1 billion people living in extreme poverty, who are the most vulnerable to food price spikes (Tigchelaar et al. 2018).

**Technological and digital innovations.** Improved seeds have the potential to transform maize value chains. Breeding techniques that employ modern technologies such as gene editing and marker assisted selection, as well as traditional breeding, are helping in the development of maize varieties that are resistant to heat, drought, disease, and pests (Cairns and Prasanna 2018; Prasanna et al. 2021), with significant benefits to both producers and consumers (Kostandini, La Rovere, and Abdoulaye 2013). Precision agriculture – which is gaining a foothold in much of the developed world, with potential expansion to the developing world – provides another prospective technological revolution for maize production (Grote et al. 2021). Digital innovations are facilitating precision maize farming in many regions, including in smallholder systems, by

offering diverse digital solutions for smallholder farmers and the food industry sector (Tsan et al. 2019). Digital solutions are expected to bring effectiveness, efficiency, and resilience to future maize value chains.

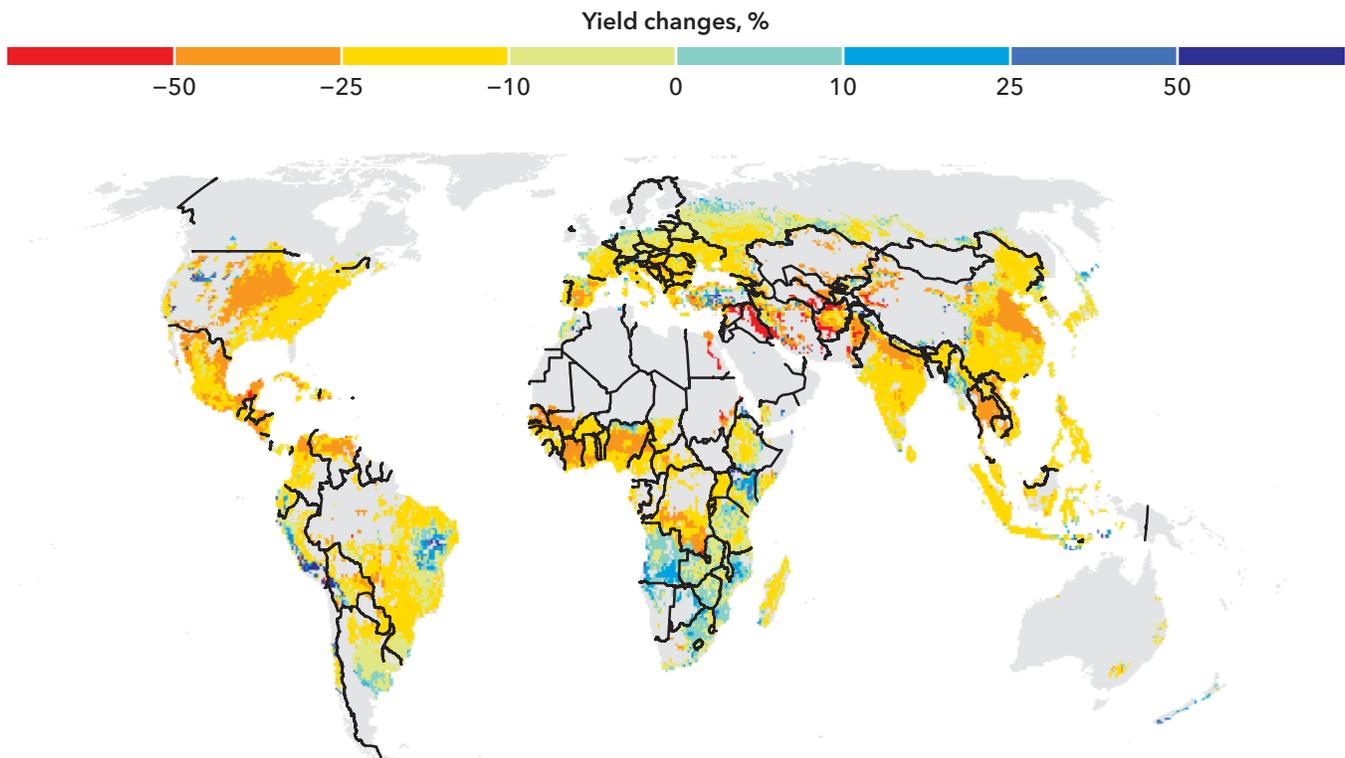
## LATEST FORESIGHT RESEARCH

Only a few recent foresight studies address maize specifically, although there are many on cereals generally. This chapter considers the studies of Kruseman et al. (2020), who looked at maize in relation to rural transformation, and Ignaciuk and Mason-D’Croz (2014), who included maize results in their modeling of adaptations to climate change, together with three recent studies that presented climate change projections on maize and implications for food security (Tigchelaar et al. 2018; Jägermeyr et al. 2021; Li et al. 2022).

Employing an IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) model with a moderate economic growth scenario across world economies under the drivers of population and income, Kruseman et al. (2020) predict a near-doubling of global maize consumption between 2010 and 2050, and changes in maize utilization (food versus feed) in the coming years. Most of the maize in South Asia is projected to be allocated to livestock feed, increasing from 34 percent in 2010 to an estimated 72 percent in 2050. The shift away from human consumption to animal feed is also expected to expand in other regions, such as the former Soviet Union, Latin America, sub-Saharan Africa, the Middle East, and North Africa (Kruseman et al. 2020). The rise in demand and dietary changes are expected to increase global maize prices. Simulation studies using the IMPACT model indicate that even in the absence of climate change, the real price of maize may increase by 50 percent by 2050 compared to 2005 prices. The surge is attributed to increased demand for both food and feed, driven by the growth in population and income, shifts toward protein-rich diets, and increased demand for biofuels from the energy sector (Ignaciuk and Mason-D’Croz 2014).

Incorporating the effects of climate change, the growth in global maize production is anticipated to only increase to 36 percent between 2010 and 2050, a considerable difference from the 72 percent growth expected

**FIGURE 2** Predicted global maize yield changes toward the end of the century under RCP 8.5, in the absence of technological change, adaptation, or market adjustments



Source: Authos based on data from Jägermeyr et al. (2021).

without climate change, with the impact varying across geographies. Maize consumption is also projected to decrease globally under the climate change scenario, while maize use patterns would remain consistent until 2050 (Kruseman et al. 2020). Furthermore, the real price of maize is expected to surge by up to 30 percent in 2050, specifically under the most extreme climate change scenario (Ignaciuk and Mason-D’Croz 2014).

Recent improved climate and crop model projections indicate a reduction of mean global maize productivity ranging from 6–24 percent by 2099 (in the absence of technological change, adaptation, or market adjustments), with the impacts starting as early as 2030 (Jägermeyr et al. 2021). By the end of the century, some 10–74 percent of current global maize cultivation areas are projected to undergo yield reductions compared to the baseline period (1983–2013) (Jägermeyr et al. 2021) (Figure 2). The biggest losses in suitable maize production area are expected in Africa and Asia (Grote et al. 2021), contributing to the projected 11 percent global average maize yield reduction by 2060–2084 relative to 1986–2005

(Li et al. 2022). Results from a study of two scenarios of warming (2°C and 4°C) show that rising instability in global grain trade and international grain prices under the warmer scenario will affect more than 800 million people who are already the most vulnerable to food price spikes (Tigchelaar et al. 2018). Given that a handful of countries dominate global maize production and trade, the occurrence of simultaneous production shocks in these countries due to rising temperatures could have tremendous impacts on global markets. These impacts, particularly increased input costs and diminished maize supplies, would pose severe challenges for people in developing countries (Tigchelaar et al. 2018).

Meeting the increasing demand for maize, adapting to changing diets, and addressing the impacts of climate change require continuous innovations across the entire maize value chain. This includes implementing innovative policies, advancing genetic and crop management techniques, fostering regional market collaborations, and amplifying investments in research and development (Erenstein et al. 2022).

## KEY GAPS AND OPPORTUNITIES FOR FORESIGHT RESEARCH

Although foresight studies on the future of cereals in general exist, only a few focus specifically on maize, mainly considering production and demand. Some research gaps related to maize value chains that merit further foresight research include: (1) the role of maize and maize-based farming systems in changing food systems that focus on nutrition, health, and inclusivity; (2) the technological, economic, and social dimensions of genetic, agronomic, and food fortification of maize on food and nutrition security, particularly in the developing world; (3) the impacts of the shifting maize demand from food to feed on the environment, nutrition, and sustainability; (4) the effects of climate change and extreme events on the quality of maize food and feed and the performance of maize supply chains; (5) cropland use shifts considering crop adaptation and profitability; and (6) the influence of green maize (maize used for food before it fully matures) on food, nutrition, and employment opportunities, particularly in sub-Saharan Africa.

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Related chapters on the future of food system drivers and impacts, regional and national perspectives, food commodities, and foresight tools are available in our [Table of Contents](#).

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## References

- Cairns, J.E., J. Chamberlin, P. Rutsaert, et al. 2021. "Challenges for Sustainable Maize Production of Smallholder Farmers in Sub-Saharan Africa." *Journal of Cereal Sciences* 101 (September): 103274. <https://doi.org/10.1016/j.jcs.2021.103274>
- Cairns, J.E., and B.M. Prasanna. 2018. "Developing and Deploying Climate-Resilient Maize Varieties in the Developing World." *Current Opinion in Plant Biology* 45B (October): 226-230. <https://doi.org/10.1016/j.pbi.2018.05.004>
- Deusch, C.A., J.J. Tewksbury, M. Tigchelaar, et al. 2018. "Increase in Crop Losses to Insect Pests in a Warming Climate." *Science* 361 (6405): 916-919. <https://doi.org/10.1126/science.aat3466>
- Elad, Y., and I. Pertot. 2014. "Climate Change Impacts on Plant Pathogens and Plant Diseases." *Journal of Crop Improvement* 28 (1): 99-139. <https://doi.org/10.1080/015427528.2014.865412>
- Erenstein, O., M. Jaleta, K. Sonder, K. Mottaleb, and B.M. Prasanna. 2022. "Global Maize Production, Consumption and Trade: Trends and R&D Implications." *Food Security* 14 (5): 1295-1319. <https://doi.org/10.1007/s12571-022-01288-7>
- FAO (Food and Agriculture Organization of the United Nations). 2024. FAOSTAT Crops and Livestock Products. Accessed October 2024. <https://www.fao.org/faostat/en/#data/QCL>
- De Groote, H., S.C. Kimenju, B. Munyua et al. 2020. "Spread and Impact of Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) in Maize Production Areas of Kenya." *Agriculture, Ecosystems and Environment* 292 (April): 106804. <https://doi.org/10.1016/j.agee.2019.106804>
- Gbegbelegbe, S., D. Chikoye, A. Alene, S. Kyei-Boahen, and G.Chigeza. 2024. "Strategic Foresight Analysis of Droughts in Southern Africa and Implications for Food Security." *Frontiers in Sustainable Food Systems* 7: 1159901. <https://doi.org/10.3389/fsufs.2023.1159901>
- Grote, U., A. Fasse, T.T. Nguyen, and O. Erenstein. 2021. "Food Security and the Dynamics of Wheat and Maize Value Chains in Africa and Asia." *Frontiers in Sustainable Food Systems* 4: 1-17. <https://doi.org/10.3389/fsufs.2020.617009>
- Ignaciuk, A., and D. Mason-D'Croz. 2014. "Modelling Adaptation to Climate Change in Agriculture." OECD Food, Agriculture and Fisheries Papers, no. 70. Paris: OECD. <http://dx.doi.org/10.1787/5jxrc1ijnbxq-en>
- Jägermeyr, J., C. Müller, A.C. Ruane et al. 2021. "Climate Impacts on Global Agriculture Emerge Earlier in New Generation of Climate and Crop Models." *Nature Food* 2 (11): 873-885. <https://doi.org/10.1038/s43016-021-00400-y>
- Kostandini, G., R. La Rovere, and T. Abdoulaye. 2013. "Potential Impacts of Increasing Average Yields and Reducing Maize Yield Variability in Africa." *Food Policy* 43: 213-226. <https://doi.org/10.1016/j.foodpol.2013.09.007>
- Kruseman, G., K.A. Mottaleb, K. Tesfaye, et al. 2020. "Rural Transformation and the Future of Cereal-Based Agri-Food Systems." *Global Food Security* 26 (May): 100441. <https://doi.org/10.1016/j.gfs.2020.100441>
- Li, K., J. Pan, W. Xiong, W. Xie, and T. Ali. 2022. "The Impact of 1.5 °C and 2.0 °C Global Warming on Global Maize Production and Trade." *Scientific Reports* 12: 17268. <https://doi.org/10.1038/s41598-022-22228-7>
- Prasanna, B.M., J.E. Cairns, P.H. Zaidi et al. 2021. "Beat the Stress: Breeding for Climate Resilience in Maize for the Tropical Rainfed Environments." *Theoretical and Applied Genetics* 134 (6): 729-1752. <https://doi.org/10.1007/s00122-021-03773-7>
- Ray, D.K., J.S. Gerber, G.K. MacDonald, and P.C. West. 2015. "Climate Variation Explains a Third of Global Crop Yield Variability." *Nature Communications* 6: 5989. <https://doi.org/10.1038/ncomms6989>
- Sileshi, G.W., and S. Gebeyehu. 2021. "Emerging Infectious Diseases Threatening Food Security and Economies in Africa." *Global Food Security* 28 (March): 100479. <https://doi.org/10.1016/j.gfs.2020.100479>
- Stevenson, J.R., N. Villoria, D. Byerlee, T. Kelley, and M. Mareid. 2013. "Green Revolution Research Saved an Estimated 18 to 27 Million Hectares from Being Brought into Agricultural Production." *PNAS* 10 (21): 8363-8368. <https://doi.org/10.1073/pnas.1208065110>
- Thornton, P.K., P.J. Ericksen, M. Herrero, and A.J. Challinor. 2014. "Climate Variability and Vulnerability to Climate Change: A Review." *Global Change Biology* 3313-3328. <https://doi.org/10.1111/gcb.12581>
- Tigchelaar, M., D.S. Battisti, R.L. Naylor, and D.K. Ray. 2018. "Future Warming Increases Probability of Globally Synchronized Maize Production Shocks." *PNAS* 115 (26): 6644-6649. <https://doi.org/10.1073/pnas.1718031115>
- Tsan, M., D.S. Totapally, D.M.C. Hailu, and B.K.C. Addom. 2019. *The Digitalization of African Agriculture Report 2018-2019*. Wageningen, Netherlands: Technical Centre for Agricultural and Rural Cooperation. <https://hdl.handle.net/10568/101498>
- van Ittersum, M.K., L.G.J. van Bussel, J. Wolf, et al. 2016. "Can Sub-Saharan Africa Feed Itself?" *PNAS* 113 (52): 14964-14969. <https://doi.org/10.1073/pnas.1610359113>

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