Maize and Global Food Security: Production Trends, Nutritional Importance and Emerging Challenges

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ABSTRACT

Maize (Zea mays L.) occupies an exceptional position within the global food system, functioning as food, livestock feed, and an industrial raw material. This paper investigates long-term production patterns, nutritional significance, prevailing patterns of use, and the key challenges shaping maize and global food security. The study draws on FAOSTAT, the OECD-FAO Agricultural Outlook, USDA and peer-reviewed research for benchmark years between 1990 and 2024. World production rose from 483.6 to 1,218.2 million tonnes (2.75 percent a year); area expansion and yield gains contributed 51.1 and 48.9 percent of this growth, although yield growth slowed to 0.84 percent a year after 2010. Production is concentrated, with the three largest producers supplying 64.7 percent of 2024 output and the top-ten Herfindahl–Hirschman Index rising from 1,607 to 1,684 between 2022 and 2024. A substantial share of grain is allocated to feed and industrial uses. Climate risk, nutritional limitations, mycotoxin exposure and affordability remain major constraints, while quality protein and biofortified maize offer nutritional advantages over conventional types. The future role of maize will depend on improved productivity, enhanced resilience, better nutritional quality and a more balanced allocation across food, feed and industry.

Keywords: maize; global food security; production trends; nutrition; food-feed competition.;

INTRODUCTION

Food security remains one of the most enduring challenges facing the global economy. The State of Food Security and Nutrition in the World 2026 reports that roughly 645 million people experienced hunger in 2025, whereas about 2.1 billion faced moderate or severe food insecurity and around 2.7 billion were unable to afford a healthy diet (FAO et al., 2026). These results underscore a key difference: while producing sufficient food globally is necessary, it alone does not ensure that every person can access adequate, nutritious diets. The report further indicates that the cost of a healthy diet increased from PPP$3.44 to PPP$4.28 per person per day between 2021 and 2025. It also finds that approximately 66.6 percent of people in Africa cannot afford a healthy diet, compared with 28.9 percent in Asia and 25.7 percent in Latin America (FAO et al., 2026). Projections imply that around 510–520 million people may still be hungry in 2030, meaning the world would remain off track for Sustainable Development Goal 2 (FAO et al., 2026).

Cereals remain fundamental to the world's food supply, and maize holds a particularly significant position because it serves multiple purposes. Unlike crops whose relevance can be assessed primarily through direct human consumption, maize circulates through several connected pathways: it is consumed directly as a staple, processed into a broad array of foods, used as feed for livestock, transformed into starches and sweeteners, and increasingly redirected toward industrial and energy applications.

Historically, maize has been especially important to the food systems of sub-Saharan Africa, Central America, and parts of Latin America. Shiferaw et al. (2011) found that maize, together with rice and wheat, provided at least 30 percent of food calories to more than 4.5 billion people in developing countries, and that maize alone accounted for more than one-fifth of food calories in parts of Africa and Mesoamerica. More recent research

characterises maize as the world's leading cereal in terms of production volume and verifies its ongoing relevance for food, feed, livelihoods, and international trade (Erenstein et al., 2022).

The paper examines maize as part of the wider food system rather than merely as an agricultural commodity. It draws on three main perspectives. First, Sen's (1981) entitlement approach highlights that hunger is linked not only to food supply but also to income, prices and people's purchasing power. Second, the FAO's four dimens-

ions of food security—availability, access, utilisation and stability—provide the analytical framework, further expanded by HLPE (2020) to include agency and sustainability. Third, the food–feed–fuel perspective recognises the multiple uses of maize and how rising demand in one sector can affect others. By bringing these perspectives together, the paper links maize production trends and regional concentration with nutritional quality, food safety and affordability, which earlier studies have often examined separately.

OBJECTIVES OF THE STUDY

- To analyse long-term trends in global maize area, production and productivity.
- To examine maize's contribution to global food and nutritional security.
- To evaluate the principal emerging challenges and opportunities that will influence maize's future role in global food security.

REVIEW OF LITERATURE

Maize occupies a central position in the global food system because of its importance as a food crop, livestock feed and industrial raw material. Shiferaw et al. (2011) highlighted its contribution to food security and rural livelihoods while identifying drought, heat, poor soil fertility, waterlogging, pests and diseases as major production constraints. Ranum et al. (2014) further demonstrated the diverse nutritional and industrial applications of maize. More recently, Erenstein et al. (2022) reported that about 56% of global dry-grain maize is used as animal feed, around 20% for non-food purposes and approximately 13% directly for human consumption. This distribution illustrates the competing uses of maize and its indirect contribution to human nutrition through livestock products.

Nutritional quality is another important dimension of maize-based food security. Although maize provides substantial dietary energy, conventional varieties are limited by the quality of their protein. Gunaratna et al. (2010) found that Quality Protein Maize (QPM) could improve weight and height gains among undernourished children, although they noted limitations in the available evidence. Nuss and Tanumihardjo (2011) similarly identified QPM as a promising approach for addressing protein inadequacy in maize-dependent populations. Joshi et al. (2022) further emphasised the nutritional and food-processing potential of improved maize varieties.

Increasing productivity is essential as expansion of cultivated land faces environmental and resource constraints. Ten Berge et al. (2019) showed that closing maize yield gaps in sub-Saharan Africa requires substantial improvements in yields, nutrient management and water availability, while excessive input use may create environmental costs.

Climate change adds further uncertainty to maize production. Zhao et al. (2017) estimated an average global maize yield reduction of about 7.4% for each 1°C increase in temperature, with considerable regional variation. Battilani et al. (2016) also projected substantially higher aflatoxin risks under warmer conditions. Recent studies further elaborate on these themes. Tigchelaar et al. (2018) found that warming increases the likelihood of concurrent production shortfalls across the principal maize-producing regions, thereby linking climate variability directly to the spatial clustering of supply. In sub-Saharan Africa, van Ittersum et al. (2016) reported substantial yield gaps in cereal production systems and cautioned that, unless yield growth accelerates, the region's reliance on cereal imports would increase. Regarding nutrition, Bouis and Saltzman (2017) reviewed the evidence for biofortified crops, including provitamin A maize, while Xu et al. (2018) synthesized research on aflatoxin

exposure in six African countries, demonstrating that food-safety risks are concentrated in places where maize is consumed daily as a staple.

DATA AND METHODOLOGY

The study follows a secondary-data, descriptive and analytical design. The principal quantitative source is FAOSTAT's Crops and Livestock Products database. Country-level production data are also obtained from FAOSTAT. Literature-based estimates from Erenstein et al. (2022) are used to discuss the broad allocation of maize among food, feed and non-food uses, and nutritional composition figures are taken from Ranum et al. (2014). Near-term production projections are drawn from the OECD-FAO Agricultural Outlook 2025–2034. Additional sources include: SOFI 2026 for food-security indicators (FAO et al., 2026); the USDA Economic Research Service Feed Outlook for United States feed and ethanol use (USDA ERS, 2026); and FAOSTAT regional aggregates, recompiled by Our World in Data, for regional yields and recent country-level outputs.

RESULTS AND DISCUSSION

Long-Term Growth of Global Maize Production

Table 1. Global Maize Area, Production and Yield, Selected Years

Year	Area harvested (million ha)	Production (million tonnes)	Yield (t/ha)
1990	131	483.6	3.69
1995	135.8	517.3	3.81
2000	136.9	591.9	4.32
2005	148.2	714.2	4.82
2010	165.26	851.9	5.16
2015	190.6	1,052.80	5.52
2020	200.2	1154	5.76
2024	209.95	1,218.20	5.8

Source: ourworldindata.org/agricultural-production; FAOSTAT, Crops and Livestock Products database;

Both area expansion and yield improvement therefore contributed to the long-term growth of global maize production, although yield growth made a somewhat larger contribution than the expansion of harvested area. From 1990 to 2024, maize area grew by about 60%, from 131.0 to nearly 210 million ha. Yield rose by 57%, from 3.69 to 5.80 t/ha. Together, these gains more than doubled production, which climbed from 483.6 to 1,218.2 million tonnes, an increase of roughly 152%. Expanding the harvested area accounted for just over half of this growth (51.1%), while higher yields explained the remaining 48.9%.

Trend Analysis and Growth Decomposition

Table 1A. Growth Statistics for Global Maize Area, Production and Yield, 1990-2024

Indicator	Area harvested	Production	Yield
CAGR 1990-2024 (%)	1.4	2.75	1.34
CAGR 1990-2000 (%)	0.44	2.04	1.59
CAGR 2000-2010 (%)	1.9	3.71	1.79
CAGR 2010-2024 (%)	1.72	2.59	0.84
Log-linear trend growth (% per year)	1.55	3.05	1.48
R^2 of log-linear trend	0.953	0.984	0.961
Mann-Kendall τ (p-value)	1.00 (<0.001)	1.00 (<0.001)	1.00 (<0.001)

Sen's slope (per year)	2.50 Mha	24.31 Mt	0.070 t/ha
Share of total log growth, 1990-2024 (%)	51.1	100	48.9

Source: FAOSTAT values in Table 1.

Global maize production grew steadily and significantly between 1990 and 2024, expanding at a compound annual rate of 2.75% (log-linear trend: 3.05% per year). Area harvested grew at 1.40% per year and yield at 1.34% per year. The trends are strong and statistically robust: the Mann-Kendall test shows a monotonic increase in all three indicators ($\tau = 1.00$, $p < 0.001$), and the log-linear models fit the data well ($R^2 = 0.953$ for area, 0.984 for production and 0.961 for yield). Sen's slope indicates that, on average, area increased by 2.50 Mha, production by 24.31 Mt and yield by 0.070 t/ha each year. The sources of growth changed over time. During 1990-2000, production growth (2.04% per year) was driven mainly by yield gains (1.59%), while area grew by only 0.44% per year. Production growth peaked in 2000-2010 at 3.71% per year, with area (1.90%) and yield (1.79%) contributing about equally. After 2010, yield growth slowed to 0.84% per year, and expansion of harvested area (1.72% per year) became the main driver of production growth (2.59%). Over the whole period, area expansion accounted for 51.1% of the total log growth in production and yield improvement for 48.9%, so the two factors contributed almost equally. The slowdown in yield growth after 2010 suggests that future production gains will depend increasingly on renewed yield improvement rather than on further expansion of cropped area.

Geographical Concentration of Production

Table 2. Leading Maize-Producing Countries, 2022

Rank	Country	Production (Mt)	Share of world production (%)
1	United States	348.8	30
2	China	277.2	23.8
3	Brazil	109.4	9.4
4	Argentina	59	5.1
5	India	33.7	2.9
6	Mexico	26.6	2.3
7	Ukraine	26.2	2.3
8	Indonesia	23.6	2
9	South Africa	16.1	1.4
10	Russia	15.9	1.4

Source: FAOSTAT, Crops and Livestock Products database, 2022.

The top ten maize-producing countries together represented roughly 81 percent of worldwide production in 2022. Production remained highly concentrated in the United States and China, which by themselves supplied slightly more than half of the global total, while Brazil was a much smaller but fast-rising third producer.

Table 2A. Leading Maize-Producing Countries, 2024

Rank	Country	Production (Mt)	Share of world production (%)
1	United States	377.6	31
2	China	294.9	24.2
3	Brazil	115	9.4
4	Argentina	57.5	4.7
5	India	40.2	3.3
6	Ukraine	26.9	2.2
7	Mexico	24.3	2

8	Canada	15.3	1.3
9	Indonesia	15.1	1.2
10	France	14.7	1.2
	World total	1,217.80	100

Source: FAOSTAT, Crops and Livestock Products database, 2024; statranker.org/economy/corn-maize-production-by-country-2026-top-50-ranking

Table 2B. Measures of Production Concentration, 2022 and 2024

Indicator	2022	2024
CR2 – United States and China (%)	53.8	55.2
CR3 – plus Brazil (%)	63.2	64.7
CR5 (%)	71.2	72.7
CR10 (%)	80.5	80.6
HHI over the top ten producers (0–10,000)	1,607	1,684

The United States and China together produced 55.2% of world output, up from 53.8% in 2022, and the three largest producers (adding Brazil) accounted for 64.7%. The HHI for the top ten producers rose from 1,607 to 1,684, and the United States' share alone increased from 30.0% to 31.0%. Concentration is therefore high and edging upward, which matters for stability: a weather, policy or trade shock in two or three countries can move world supply and prices. Two cautions apply. First, the HHI is a lower bound, because countries outside the top ten are not included individually. Second, the 2022 figures come from the earlier extraction and may be affected by FAOSTAT revisions.

Maize: Food, Feed and Other Uses

Table 3. Estimated Global Allocation of Dry-Grain Maize by Major Use

Use	Approximate share of global utilisation (%)
Animal feed	56
Industrial and other non-food uses	20
Direct human food	13
Seed, losses and other (residual)	11

Source: Erenstein et al. (2022), Food Security.

Erenstein et al. (2022) estimate that globally about 56 percent of dry-grain maize is used as animal feed, around one-fifth for industrial and other non-food purposes, and roughly 13 percent as direct human food, with the remainder going to seed, losses and minor uses. Maize food security therefore cannot be judged from direct consumption alone. Feed supports food security indirectly through meat, milk and eggs, while industrial uses such as starch, sweeteners and biofuel compete with both food and feed for the same grain. Growing feed and industrial demand can thus push up prices in periods of supply stress, even though direct food use is a small share of the total. These shares are aggregate estimates for the period covered by Erenstein et al. (2022) and may not reflect recent changes in biofuel and feed demand.

Nutritional Importance of Maize

Table 4. Nutritional Composition of Maize Grain (per 100 g, approximate)

Component	Approximate value
Starch	72 g
Protein	10 g

Fat	4 g
Energy	365 kcal

Source: Ranum et al. (2014).

Ranum et al. (2014) report that maize grain contains about 72 percent starch, 10 percent protein and 4 percent fat, providing roughly 365 kilocalories per 100 grams. Its nutritional impact varies widely across countries, however, and global averages can mask heavy dependence within particular populations. Where maize dominates the diet, its low lysine and tryptophan content lowers protein quality even when calorie intake appears adequate. Improved varieties differ: Quality Protein Maize contains substantially more lysine and tryptophan, and evidence reviewed by Gunaratna et al. (2010) suggests benefits for child growth in maize-dependent populations, although it cannot substitute for a diverse diet.

Conventional, Improved and Biofortified Maize

The composition and health effects discussed above apply to conventional maize and should not be generalised to improved varieties, which differ in the nutrients they target and in the strength of the evidence behind them. Table 4 distinguishes conventional maize, quality protein maize (QPM), provitamin A (orange) maize and zinc-biofortified maize. Industrial fortification of milled maize flour is a separate intervention (Ranum et al., 2014) and is not a property of the grain itself. An important qualification concerns reach: because most global maize is used for feed or industrial purposes (Table 3), improved nutritional varieties influence food security only where maize is eaten directly, notably in sub-Saharan Africa and Mesoamerica. The nutritional contribution of the world maize supply is therefore dominated by conventional maize and by the indirect pathway through livestock products.

Table 4A. Nutritional Characteristics of Conventional, Improved and Biofortified Maize

Maize type	Principal nutritional trait	Evidence of benefit	Main limitations
Conventional maize	Energy-dense (about 72 g starch, 10 g protein, 4 g fat and 365 kcal per 100 g; Table 4); protein low in lysine and tryptophan; white grain contains little provitamin A	Benchmark for comparison	Protein quality and micronutrient adequacy are limited where maize is the main staple (Ranum et al., 2014)
Quality protein maize (QPM)	Substantially higher lysine and tryptophan than conventional maize (Nuss & Tanumihardjo, 2011)	Meta-analysis of community-based studies suggests improved weight and height gains in undernourished children (Gunaratna et al., 2010)	Limited and heterogeneous evidence; requires seed systems and adoption; not a substitute for a diverse diet
Provitamin A (orange) maize	Higher provitamin A carotenoid content, targeting vitamin A deficiency	Assessed within the Harvest Plus evidence base (Bouis & Saltzman, 2017)	Depends on carotenoid retention in storage and processing and on acceptance of the grain color in populations accustomed to white maize
Zinc-biofortified maize	Higher grain zinc concentration, targeting zinc deficiency	Assessed within the Harvest Plus evidence base (Bouis & Saltzman, 2017);	Zinc absorption is limited by phytate in maize; reach depends on adoption in maize-dependent populations

Source: Ranum et al. (2014), Nuss and Tanumihardjo (2011), Gunaratna et al. (2010) and Bouis and Saltzman (2017).

Maize and the Four Dimensions of Food Security

Table 5. Pathways Linking Maize with the Four Dimensions of Food Security

Dimension	Contribution of maize	Principal risk
Availability	Large-scale cereal production, rising yields	Production shocks, weather variability
Access	Farm income, affordable staple food, trade	Price increases, income shocks for net buyers
Utilisation	Calories, protein, fortified/biofortified products	Nutrient limitations (lysine, tryptophan), mycotoxins
Stability	Storage, diversified production and trade	Climate shocks, trade disruption, export concentration

This perspective helps clarify why the link between maize and food security cannot be represented by a straightforward rule in which greater maize production automatically leads to greater food security. Maize's contribution instead depends on whether it is available, affordable, nutritionally adequate, safe and reliably supplied, dimensions that interact with one another rather than operating independently.

Emerging Challenges

Climate Change

The first major challenge concerns climate vulnerability. Higher temperatures, drought, irregular rainfall and extreme weather events can reduce maize productivity, particularly in rain-fed production systems; as noted above, Zhao et al. (2017) estimated an average maize-yield response of roughly minus 7.4 percent per 1°C of warming in the absence of adaptation and genetic improvement. Climate risk operates through variability as well as through mean warming. Tigchelaar et al. (2018) found that warming raises the probability of simultaneous production shocks across the main maize-producing regions, which is significant because the three largest producers supplied about 65 percent of world output in 2024 .

Persistent Yield Gaps

A second challenge lies in the substantial gap between potential and realised maize yields across many low-income production systems. Constraints on input access, limited availability of improved seed, soil nutrient depletion, weak credit systems, inadequate extension services and market uncertainty all suppress farm-level productivity.

Food-Feed-Industrial Competition

Maize's versatility is both a strength and a source of tension, since the crop is needed for food, livestock feed, starch and sweeteners, and industrial and biofuel uses. Ranum et al. (2014) noted the rapid growth of fuel-related use and the potential for competition among uses to influence prices. In the United States, the world's largest producer, USDA ERS (2026) forecasts 2025/26 use at about 5.55 billion bushels (141 Mt) for ethanol and by-products and 6.35 billion bushels (161 Mt) for feed and residual use, together roughly 70 percent of the 2025 crop of about 17.0 billion bushels (432 Mt; USDA, 2026). Because the OECD/FAO outlook expects feed and biofuel demand to drive maize growth to 2034, the allocation of grain between food and non-food uses depends on energy and livestock policy, such as biofuel mandates, as well as on market forces.

Affordability and Access

The average cost of a healthy diet rose from PPP$3.44 to PPP$4.28 per person per day over 2021-2025. Although the share unable to afford such a diet fell from 37.4% to 32.7%, about 2.7 billion people, including two-thirds (66.6%) of Africans, still could not in 2025 (FAO et al., 2026). Maize is often among the cheapest sources of dietary energy, but a cheap staple does not make a healthy diet affordable, as maize-based diets leave gaps in protein quality, micronutrients and diversity (see The Nutrition Challenge). Because maize prices pass through

feed and energy markets, livestock or biofuel demand shocks can raise staple prices for net-buying households, such as the urban poor.

International Trade Concentration

Trade allows maize-deficit countries to draw on supplies from surplus-producing regions, but it also exposes them to international shocks. The OECD-FAO Agricultural Outlook 2025–2034 projects that global maize production will rise by roughly 188 million tonnes to about 1.4 billion tonnes by 2034, driven mainly by yield improvements rather than area expansion, with the largest absolute increases expected in the United States, Brazil and China (OECD/FAO, 2025).

Food Safety

Mycotoxin contamination is a distinct threat: grain may remain available but be unsafe to eat, and climate change may shift where the risk is greatest (Battilani et al., 2016, for aflatoxin in European maize). Where maize is a staple, exposure is substantial. In a review of aflatoxin biomarker studies in six African countries, Xu et al. (2018) found that contamination of household maize varied widely: Kenyan geometric means were 12.9 and 26.0 µg/kg in 2005 and 2006 but 1.95 µg/kg in 2007, and a Tanzanian study recorded 2 to 1,081 µg/kg. High intake (about 171 g per person per day in Kenya, 128 g in Tanzania) raises exposure. Aflatoxin B1 is an IARC Group 1 carcinogen linked to liver cancer, and acute outbreaks can be fatal, as in Kenya in 2004 (125 deaths). Longer storage was associated with higher contamination in Uganda (30.2 against 20.5 µg/kg), and the review notes weak regulatory enforcement and treats the link to child stunting as unresolved (Xu et al., 2018). Mycotoxins thus reduce the safe food supply even when yields are adequate.

The Nutrition Challenge

A final priority is to avoid treating calorie sufficiency as synonymous with nutritional adequacy. Maize can provide excellent, affordable dietary energy, yet maize-dependent diets may not offer enough dietary diversity. The nature of the challenge differs by maize type. Conventional maize supplies energy but limited protein quality, whereas QPM and biofortified varieties address specific deficiencies but reach only a fraction of consumers, and their impact depends on seed systems, consumer acceptance and targeting to populations in which maize is the main staple.

OPPORTUNITIES TO STRENGTHEN THE ROLE OF MAIZE

Several developments could expand maize's contribution to future food security. Improvements in sustainable yields can increase output without a proportional rise in land under cultivation, while climate-resilient breeding can lower exposure to heat, drought, and emerging pests and diseases. Biofortification and Quality Protein Maize can enhance the nutritional quality of diets that rely on maize, and better storage along with improved post-harvest handling can raise the effective food supply without requiring comparable increases in production at the farm level.

POLICY IMPLICATIONS

The findings point to several policy priorities. Investment in maize research should increasingly combine yield improvement with heat tolerance, drought tolerance and resistance to pests and diseases, since productivity gains rather than area expansion have driven most of the growth observed to date. Countries where maize functions as a major staple should integrate agricultural policy with nutrition policy, and Quality Protein Maize, provitamin-A maize, zinc biofortification and appropriate fortification programmes deserve attention wherever local dietary patterns justify them. Reduction of post-harvest loss and mycotoxin contamination should be treated as food-security interventions in their own right, rather than as purely technical storage concerns. In addition, international trade is still needed to offset spatially uneven maize production and demand. More resilient trade and storage systems can also help restrict the spread of localised production shocks into broader food insecurity.

CONCLUSION

Maize is a cornerstone of the global food system, but its contribution to food security is more complex than production volume suggests. For millions of households, especially in parts of Africa and Latin America, it is a direct source of daily food and energy. Globally, it is equally a livestock feed, an industrial input and a traded commodity: in the United States, ethanol and feed together are forecast to take about 70 per cent of the 2025 crop (USDA ERS, 2026).

The updated data show how uneven the gains are. World production reached 1,218.2 million tonnes in 2024, growing 2.75 per cent a year since 1990. Yield growth slowed to 0.84 per cent a year after 2010, so area expansion supplied about two-thirds of recent growth. Production is also concentrated, with the three largest producers supplying 64.7 per cent of 2024 output, and African yields remain well below Asian ones (2.07 against 5.85 t/ha). Access is a further constraint: about 2.7 billion people, including two-thirds of Africa's population, could not afford a healthy diet in 2025 (FAO et al., 2026), and maize-based diets leave nutritional gaps while mycotoxins can make available grain unsafe.

Future progress will therefore depend more on renewed yield growth than on expanding cropped land. Climate-resilient varieties, better soil and water management, improved storage, aflatoxin control, and Quality Protein Maize and biofortified varieties can all strengthen maize's role. Maize is best understood as part of a food system linking farms, livestock, industry, trade and nutrition, and more of it will improve food security only if affordability, safety and nutritional quality improve alongside volume.

ETHICAL APPROVAL: This study is based entirely on secondary, publicly available data and did not involve human participants or animals.

CONFLICT OF INTEREST: NO.

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