GLOBAL ALLIANCE FOR THE FUTURE OF FOOD

Toxic Dependency: How Agrochemicals Lock In Food System Vulnerability

Pathways for Action and Resiliency



Global Alliance for the Future Of Food **October 2026**

DISCLAIMER

This document was commissioned by the Global Alliance for the Future of Food, for use by Global Alliance members and partners to stimulate discussion about critical issues related to food systems transformation and to help guide collective action. The Global Alliance has chosen to make it available to the broader community to contribute to the discussion about sustainable food systems transformation.

Copyright © 2026 Global Alliance for the Future of Food

This work is licensed under a Creative Commons Attribution–NonCommercial 4.0 International License.

Suggestion for referencing: Global Alliance for the Future of Food, Toxic Dependency: *How Agrochemicals Lock In Food System Vulnerability*, Pathways for Action and Resiliency n.p.: Global Alliance for the Future of Food, 2026. futureoffood.org

Cover photo credit: Jorge Vinueza, Inventario Documental, Ecuador

Photo credit: David Mills, WorldFish

Contents

Foreword 4

Executive Summary 5

Key Messages 7

Compendium Approach 8

- Expert Partner Network 8

Defining Agrochemicals 11

- Synthetic Pesticides 11
- Synthetic Nitrogen Fertilizers 13

01

Dependency Across the Food System 14

- The Links Between Fossil Fuels and Agrochemicals 14
- Expanding Demand in Industrial Food Systems 15

02

Assessing the Risks and Impacts 19

- **Environmental Impacts:** How agrochemicals destabilize ecological systems and undermine resilience 21
- **Health Impacts:** How agrochemicals disrupt vital biological functions 25
- **Social and Economic Impacts:** How agrochemical systems undermine livelihoods, knowledge, and power 30
- Reinforcing feedback loops 33

03

Laying Out the Lock-Ins 34

- Corporate Concentration 35
- Technology Treadmill 40
- Public Policy and Finance 43
- Dominant Narratives 47

04

Action Pathways for People and Planet 49

- Structural Solutions and Coordinated Action 49
- Four Action Pathways: An Overview 51
- **Pathway 1:** Expand the evidence base and reframe narratives 54
- **Pathway 2:** Align policy, regulation, and finance 56
- **Pathway 3:** rebalance power and foster accountability 59
- **Pathway 4:** Co-create enabling conditions for agrochemical transitions 61

Conclusion 68

Glossary 69

Endnotes 70

Acknowledgements 78



Foreword

From the lush north coast of Kauai, Hawaii, to the checkerboard-flat Yucatán Peninsula, from the mountains of Sri Lanka to the verdant fields of Andhra Pradesh, India, I've witnessed firsthand the promise of ecological approaches to farming. My notebooks are filled with example after example of what becomes possible when farmers transition away from synthetic fertilizers and pesticides: farmer and community health improves, resilience grows in the face of climate shocks, crops flourish, biodiversity returns, and so much more.

For more than 25 years, I've been tracking the efforts of farmers and fishers, communities and policymakers working to reduce reliance on synthetic fertilizers and pesticides. Today, I'm encouraged by the global momentum we're seeing around this transition. Our hope is that the framing, analysis, and resources we've gathered in this compendium can help accelerate it.

Here, we bring together the expertise of some of the world's leading advocates, researchers, and organizations on the frontlines of this work. With their wisdom, we explore the intertwined connections among fossil fuels, food systems, and agrochemicals—and the far-reaching consequences of our dependence on them. We also illuminate what is at stake and, critically, what we can do about it.

Whether you come to this work through biodiversity, climate, public health, Indigenous rights, farmer and fisher sovereignty, or another entry point, we hope these pages help make visible the connections to agrochemicals—and the opportunities for action.

Brace yourself: Much of what follows is sobering. These pages lay bare the enormous risks of a food production paradigm dependent on synthetic fertilizers and pesticides. But keep yourself open, too, to the possibilities you'll encounter: the extraordinary potential for abundance and health, for thriving biodiversity, for climate mitigation and resilience, when we support a transition away from this dependence.

We are deeply grateful to the contributors you'll meet in these pages—not only for their collaborative engagement in this process but also for the work they do in the world. We're also enormously proud of our members and their leadership in philanthropy as champions of principles-based food systems transformation. And, of course, we hold immense gratitude for the farmers and fishers, water and land stewards, Indigenous Peoples and communities who are already showing us what another food future can look like.

More than 60 years ago, environmentalist Rachel Carson wrote in *Silent Spring*:

> *A Who's Who of pesticides is therefore of concern to us all. If we are going to live so intimately with these chemicals—eating and drinking them, taking them into the very marrow of our bones—we had better know something about their nature and their power.*
>
> **—Rachel Carson**

That call feels as urgent today as it did then. We hope this compendium helps you better understand the nature and power of pesticides and synthetic fertilizers—and, just as importantly, the power we have to move beyond our dependence on them. And helps to show the systemic nature of our crises and how tackling agrochemicals can be a powerful lever.

With this understanding, we hope to catalyze greater action and investment toward a shared vision: a world in which our food systems protect biodiversity, help stabilize the climate, are a source of bounty and health, and strengthen the resilience of communities.

That future is already being cultivated in fields, forests, waters, and communities around the world. We look forward to working with you to help it flourish.

Anna Lappé

Executive Director,
Global Alliance for the Future of Food





Executive Summary

Food systems sit at the heart of the world's most urgent challenges and represent one of the greatest opportunities to address them. This compendium focuses on one critical, underexamined piece of that puzzle: agrochemicals—specifically synthetic fertilizers and pesticides—and the fossil fuel dependence that underpins them. We publish this at a moment of acute urgency. A historic fertilizer crisis, driven by the US–Israel war in Iran and the disruption of the Strait of Hormuz, has placed fossil fuel dependence in food systems under an unprecedented spotlight. The vulnerabilities this compendium describes are not abstract or future risks; they are unfolding in real time, now.

The Structural Dynamics of Agrochemical Dependence

Global pesticide use has more than doubled since 1990; nitrogen fertilizer use has grown eightfold since the 1960s. This staggering growth and dependence persist not because alternatives don't exist, but because policy subsidies, fossil fuel infrastructure, corporate concentration, and dominant narratives keep agrochemical use in place.

This compendium's central finding is that the harms of agrochemical-dependent food systems—environmental degradation, chronic disease, eroded farmer livelihoods—are not merely outcomes of this system. They are feedback loops that actively reinforce it: Degraded soils demand more inputs; health harms are managed downstream through healthcare rather than prevented; and economic pressures narrow farmers' abilities to exit chemical-intensive pathways. Understanding these dynamics as structural, rather than as isolated market failures, is essential to identifying where meaningful change is possible.

Why This Matters

Global Alliance members and the broader philanthropic community have identified the food–health–energy nexus as a strategic priority. Agrochemicals sit precisely at this nexus and represent a rare convergence point for funders: Health funders enter through toxic chemical exposure; climate funders through fossil fuel demand and greenhouse gas emissions; biodiversity funders through pollinator collapse and ecosystem degradation; food sovereignty funders through farmer autonomy and land rights.

Despite this convergence, funder engagement remains siloed. Greater collaboration across funders and the broad community of actors and organizations working on these issues could unlock significant capital, shared evidence bases, and unified advocacy—but only if funders and partners working from different entry points are connected and aligned around shared strategic priorities.

As a strategic alliance of philanthropic foundations, our approach is grounded in a systems perspective, without privileging one impact over another and without leaving blind spots unnamed. Central to this systems approach is a non-negotiable commitment: No place, and no people, should unfairly carry the burdens of agrochemical exposure and impact.





Photo credit: S. Quinn, CIP—Centro Internacional de la Papa

What This Compendium Offers

Drawing on contributions from twenty-nine expert partners, including researchers, farmer movements, Indigenous organizations, and civil society networks from around the globe, this compendium:

- **Maps the system:** Traces how fossil fuel dependence flows through agrochemical production to commodity crop production, industrial livestock, ultra-processed foods, and biofuels—and back again—in a self-reinforcing cycle.
- **Aggregates the evidence and documents the true costs:** Brings together evidence on the environmental costs (including planetary boundary breaches, biodiversity collapse, an estimated USD 1.45 trillion annually in nitrogen pollution costs alone); the health costs (USD 816 billion annually in toxic exposure, alongside links to cancer, neurological disease, and reproductive harm); and the social costs (including farmer debt, eroded sovereignty, and chemical dependency).
- **Identifies the lock-ins:** Examines the corporate concentration, technology treadmill, policy and subsidy structures, and legitimizing narratives that perpetuate this system despite mounting evidence of its harm.
- **Charts four interconnected pathways for change:** Identifies opportunities for funders and partners to align strategies that expand the evidence base and reframe narratives; align policy, regulation, and finance; rebalance power and foster accountability; and create enabling conditions for agrochemical transitions.

In this compendium we explore the importance of moving toward food production practices that reduce or fully eliminate the reliance on synthetic nitrogen fertilizer and synthetic pesticides. These practices range from bringing regenerative practices to monoculture production to adopting certified organic agriculture in regions where organic is codified to using agroecological practices as defined by the 13 principles of agroecology.

Three Shifts We Hope This Report Inspires

1. **From invisible harm to accounting for true costs:** Equip readers, wherever they sit in the philanthropic or policy landscape, to understand and communicate the full costs of agrochemical dependence.
2. **From normalization to shock:** Confront how the use of cancer-causing chemicals and endocrine-disrupting pesticides on the land and in the water systems that feed us came to be accepted as ordinary.
3. **From hidden link to linchpin:** Recognize that agrochemicals are not a marginal climate or health issue but an essential structural support for industrial animal agriculture, monocultures, and industrial aquaculture. Reducing dependence on these inputs can help create the conditions for systems-level change.

The Moment for Action

The evidence has never been clearer, and momentum is building across civil society, where decades of advocacy are converging into more unified global platforms; among governments that are developing new strategies and policies to support agroecology and regenerative approaches; and across funders, who are increasingly recognizing shared purpose to address agrochemicals. The transition to resilient, agroecological food systems is not a hypothetical future state; it is already underway in communities, regions, and national programs around the world. What is needed now is coordinated resourcing that matches the scale and urgency of the challenge.

This compendium is offered as a resource for that coordination: a shared tool to help funders, policymakers, and advocates move from recognizing the problem to acting together on its solutions.

Key Messages

01 Agrochemical-dependent food systems are a systemic risk—destabilizing supply chains, ecosystems, human health, and ultimately food security itself

When fossil fuel supply chains are disrupted by conflict or crisis, food systems dependent on synthetic inputs are also impacted, leading to hunger and food insecurity. This is not a hypothetical risk. It has been well-documented since the rise of this dependency, and has become especially acute in recent years. Ecological approaches to food production on land and in water, which build on natural processes, are more resilient. Funding the transition away from agrochemical dependence toward ecological approaches is as much a risk management strategy as it is a values-based one.

02 Agrochemicals are a linchpin that holds industrial food systems in place, linking issues across food, health, and energy systems

Fossil fuel–derived pesticides and synthetic fertilizers sit at the centre of a web of interconnected crises: climate change, biodiversity collapse, chronic disease, and farmer poverty. Whatever aspect of food systems transformation is the entry point, addressing agrochemical dependency—whether by reducing agrochemical use or phasing them out—can help catalyze the systemic changes required to improve food security, health, and environmental outcomes.

03 The harms are structural, and therefore the solutions must also be structural

Agrochemical dependence persists not because viable alternatives do not exist. Rather, this dependency persists for different reasons in different geographies, including a lack of supportive policies, environmentally harmful subsidies, insufficient funding to transition to ecological approaches, corporate concentration, and dominant narratives designed to make alternatives seem ineffective. Piecemeal interventions aren't enough. Philanthropy can have greater impact by funding systemic levers for a just transition, supporting efforts to phase out highly hazardous pesticides, repurposing harmful subsidies to fund and de-risk regenerative and agroecological transitions at scale, and supporting legal and governance efforts to rebalance power and restore accountability.



04 Industrial-scale monocultures dependent on agrochemicals fail to deliver on health, food security, and nutrition

Food systems oriented around yields rather than nourishment fall short on both counts. More than half the world's industrial-scale monocultures dependent on agrochemicals are grown for animal feed or biofuels, not human consumption, while agrochemical exposure is linked to cancers, neurological disorders, and reproductive harm. Food systems that are genuinely resilient must also be safe, diverse, and ecologically intact, and regenerative and agroecological approaches are designed to make them just that.

05 Agrochemicals reduce the resilience of agricultural and marine ecosystems

Agrochemicals contribute to water contamination, alter nitrogen and phosphorus cycles, and destabilize the ecological foundations upon which food production depends. Synthetic fertilizers degrade soil microbiota, structure, and carbon cycling, while pesticides pose hazards to the invertebrates that maintain fertility and water retention. Advancing action on global commitments is critical to phase out highly hazardous pesticides (HHPs) and reduce agrochemical use, as agreed under the United Nations Convention on Biological Diversity.

06 Transitions away from agrochemical dependency are underway, reflecting growing evidence and an abundance of solution pathways

The evidence is now clear that diversified, agroecological farming systems are significantly more resilient to climate shocks than industrial monocultures. For funders and partners investing in climate adaptation, food security, or resilient livelihoods, supporting the agroecological transition is an evidence-based solution. From Andhra Pradesh's million-farmer natural farming program to Brazil's school food procurement program, which includes a commitment to procure organic food, to organic cotton projects in Egypt, Tanzania, and Benin that are bringing thousands of hectares under sustainable management, agroecological transitions are scaling around the world. The question is no longer whether reducing dependency on agrochemicals is possible, but how to expedite this transition. Philanthropy, leveraging public and private finance, must coordinate to support and catalyze a transition that matches the scale and timeframe required, and to counter the resources devoted to maintaining the status quo.

Compendium Approach

The Global Alliance for the Future of Food commissioned this compendium to understand the dynamics that perpetuate fossil fuel–dependent, agrochemical-intensive food systems and identify pathways toward more resilient and healthy solutions.

Our 2023 report Power Shift: Why We Need to Wean Industrial Food Systems Off Fossil Fuels identified phasing out of fossil fuel–based agrochemicals and transitioning to regenerative and agroecological as a high-impact opportunity for greater collaboration across the food–energy nexus. Since then, we have been engaging with funders of all types to build alignment around systemic solution pathways that reduce reliance on fossil fuel–dependent agrochemicals and accelerate agroecological transitions.

This process has revealed that agrochemicals can be a point of convergence: Agrochemicals are a priority issue for many food systems funders, but funders working from different entry points need to be connected and aligned. Health funders focus on the entry point of toxic chemicals; climate funders on their links to fossil fuels; still other funders on farmer livelihoods, biodiversity, and related priorities. The solution pathways presented here provide co-benefits across these agendas and offer strategies that can then be scaled by governments and the private sector to enhance resilience across the food system.

With this in mind, this report is inspired by True Cost Accounting, a multiple capitals-based approach to systems thinking that explores the full range of visible and invisible externalities and impacts that are relevant to food systems, including political, social, economic, environmental, and human factors. Recognizing the broad array of evidence, knowledge, and expertise that is required, we brought together a partner network with a diverse range of expertise.

With volatility in global supply chains—from the COVID-19 pandemic, to the 2022 Russian invasion of Ukraine, to the 2026 US–Israel war in Iran—the risk of fossil fuel–dependent food systems is now impossible to ignore, creating a timely opportunity to transform food systems.

Expert Partner Network

The people, organizations, and networks of practitioners, researchers, farmers, fishers, food providers, Indigenous Peoples, and foundations that make up this group contributed an extraordinary body of evidence, research, stories, and analysis—far more than could fit into a report that is both comprehensive and accessible, or capture the full and ever-growing body of evidence on agrochemicals. The contributions of the twenty-nine expert partners were synthesized by a research lead and a team of journalists into a cohesive body of work. This was then further refined by the Global Alliance Secretariat and members, with input from six reviewers.

Contributors and Reviewers

The **Action Group on Erosion, Technology and Concentration (ETC Group)** is a Canadian-based international civil society organization that monitors the impacts of new technologies and corporate concentration on biodiversity, agriculture, and human rights, with particular focus on the global food system.
Contribution focus: Corporate concentration in the agrochemical sector (with GRAIN).
Website: www.etcgroup.org

ActionAid is an international NGO working as a federation across 45 countries, partnering with communities on development issues including women's rights, land, climate, and emergency response, with a particular focus on poverty and justice.
Contribution focus: Agricultural subsidies reform; farmer experiences.
Website: www.actionaid.org

Alliance for Food Sovereignty in Africa (AFSA) is a broad alliance of civil society organizations working to advance food sovereignty and agroecology across Africa. Operating as a network of networks, AFSA brings together 41 members active in 50 African countries, including food producer networks, Indigenous Peoples' organizations, and consumer movements.
Contribution focus: Agricultural subsidies reform; farmer experiences.
Website: www.afsafrica.org

Center for International Environmental Law (CIEL) uses the power of law to protect the environment, promote human rights, and ensure a just and sustainable society. CIEL seeks a world where the law reflects the interconnection between humans and the environment, respects the limits of the planet, protects the dignity and equality of each person, and encourages all of Earth's inhabitants to live in balance with each other.
Contribution focus: Reviewer.
Website: www.ciel.org

The **Centre for Pesticide Suicide Prevention (CPSP), University of Edinburgh** works to reduce the number of pesticide suicides worldwide. CPSP is a philanthropically funded research and policy initiative within the University of Edinburgh.
Contribution focus: Reviewer.
Website: www.centrepsp.org

ClimateWorks Foundation is a catalyst for accelerating climate progress, driving bold solutions that benefit people and the planet. ClimateWorks connects funders and implementing organizations worldwide to create and scale transformative solutions across sectors and geographies.
Contribution focus: Narratives in agricultural food systems; reviewer.
Website: www.climateworks.org

The **European Federation of Food, Agriculture, and Tourism Trade Unions (EFFAT)** represents over 120 trade unions and 2.6 million workers across Europe. EFFAT advocates for workers' rights, decent working conditions, and fair labour standards across agri-food supply chains.
Contribution focus: Worker exposure to agrochemicals.
Website: www.effat.org

The **Eastern and Southern Africa Small Scale Farmers Forum (ESAFF)** is a farmer-led movement active in 16 countries that enables small-scale farmers to speak as a united voice so their recommendations shape policies at national, regional, and global levels.
Contribution focus: Agricultural subsidies reform (Zambia and Zimbabwe, with ActionAid).
Website: www.esaff.org

FIAN International is a global human rights organization that advocates for the right to adequate food and nutrition, and works to eradicate unjust practices that prevent communities and individuals from feeding themselves with dignity and self-determination.
Contribution focus: Impacts of agrochemicals and actions to address them.
Website: www.fian.org

Foodrise is a U.K.-based charity working to transform the food system for climate, nature, and justice by taking bold action to uncover root causes of injustice and expose how corporate power exploits people and the planet.
Contribution focus: The role of fertilizer corporations in food system harm.
Website: www.foodrise.org.uk

Friends of the Earth is one of the world's largest grassroots environmental networks, with member groups in 73 countries campaigning on climate, biodiversity, land, food systems, and corporate accountability through local action and international advocacy.
Contribution focus: Greenwashing of regenerative agriculture claims.
Website: www.foe.org

Global Collaboration for Resilient Food Systems (CRFS) is a grantmaking program of the McKnight Foundation that supports agricultural research and practice in Sub-Saharan Africa and Latin America. CRFS funds collaborative, farmer-centred approaches to building resilient, agroecologically grounded food systems.
Contribution focus: Bioinputs innovation and farmer perspectives.
Website: www.mcknight.org/programs/global-foods

GRAIN is an international nonprofit that supports small farmers and social movements in their struggles for community-controlled, biodiversity-based food systems, with a central focus on resisting growing corporate control over food production, markets, and trade.
Contribution focus: Corporate concentration in the agrochemical sector (with ETC Group).
Website: www.grain.org

Health and Environment Alliance (HEAL) works to ensure that health evidence and health voices are heard by policymakers, raising awareness of how the environment affects health and shaping laws and policies for planetary and human health. Its work is supported by more than 70 member organizations.
Contribution focus: Human health impacts of agrochemical exposure.
Website: www.env-health.org

IFOAM - Organics International is the worldwide umbrella organization for the organic movement, representing over 700 affiliates in over 100 countries. Founded in 1972, IFOAM - Organics advocates for sustainable agriculture, sets international organic standards, builds capacity in farmer-led organizations working for organics and agroecology, and unites stakeholders in advocacy and communities of practice to expand organic and agroecological food systems.
Contribution focus: Transitions from conventional to agrochemical-free organic farming.
Website: www.ifoam.bio

The **International Institute for Sustainable Development (IISD)** is an independent think tank committed to creating a world where people and the planet thrive by transforming bold ideas into real-world change through trusted research, policy advice, and collaboration.
Contribution focus: Agricultural subsidies reform analysis.
Website: www.iisd.org

The **International Panel of Experts on Sustainable Food Systems (IPES-Food)** is an independent nonprofit founded in 2015 that brings together researchers and practitioners from diverse disciplines to produce policy-oriented research and recommendations for sustainable food systems globally.
Contribution focus: Lock-ins preventing food systems transformation.
Website: www.ipes-food.org

Jennifer Clapp is a Tier I Canada Research Chair in Global Food Security and Sustainability and a professor in the School of Environment, Resources and Sustainability at the University of Waterloo, Canada. Dr. Clapp is a member of the International Panel of Experts on Sustainable Food Systems (IPES-Food) and the Scientific Advisory Committee of the UN Food Systems Coordination Hub.
Contribution focus: Lock-ins in the global food system; reviewer.
Website: www.uwaterloo.ca

Joe Yates is from the London School of Hygiene & Tropical Medicine and co-leads the Agriculture, Nutrition & Health (ANH) Academy, a science-policy platform that brings together researchers, practitioners, and policymakers working to improve nutrition and health through better agriculture and food systems. The ANH has more than 13,000 members across 160+ countries.
Contribution focus: Reviewer.

Liz Willetts is a science-policy expert on the health–environment nexus with more than 20 years' experience working with governments, international institutions, and UN agencies. She is the former Planetary Health Policy Director at the Harvard T.H. Chan School of Public Health.
Contribution focus: Biodiversity impacts of agrochemical food systems.
Website: www.iisd.org

Pacific Environment confronts urgent environmental issues by connecting local and global movements, catalyzing policy change, and inspiring action. Together with partners, it promotes a healthy climate, reduces pollution, and conserves biodiversity to help build an equitable and thriving future.
Contribution focus: Petrochemical build-out in China and its links to the agrochemical industry.
Website: www.pacificenvironment.org

Pesticide Action & Agroecology Network North America (PANNA) uses science, communications, and coalition organizing to create a just, healthy, and equitable food system. PANNA works with farmers, farmworkers, and rural communities on the frontlines to tackle the pesticide problem and reclaim the future of food and farming.
Contribution focus: Impacts of agrochemical-dominant industry.
Website: www.panna.org

Pesticide Action Network (PAN International) is a network of more than 600 participating nongovernmental organizations, institutions, and individuals in over 90 countries working to replace hazardous pesticides with ecologically sound and socially just alternatives.
Contribution focus: International pesticide agreements and trade policy.
Website: www.pan-international.org

Pesticide Action Network UK (PAN UK) is a British NGO working to eliminate hazardous pesticides and promote sustainable agriculture through research, policy advocacy, and international development work on pesticide alternatives and food systems reform.
Contribution focus: Legal and regulatory agreements and agrochemical value chains; reviewer.
Website: www.pan-uk.org

Scan the Horizon is a research and foresight organization focused on emerging technologies and their implications for food and agriculture systems.
Contribution focus: Digital agriculture and emerging technology in food systems.
Website: www.scanthehorizon.org

Self Employed Women's Association (SEWA) is India's largest national trade union centre for women workers in the informal economy. Founded in 1972, SEWA has more than 3.7 million members—poor, self-employed women workers across 20 states—and works toward full employment and self-reliance for its members.
Contribution focus: Conditions for informal women workers in food and agricultural supply chains.
Website: www.sewa.org

Shamba Centre for Food & Climate is a nonprofit working to achieve zero hunger sustainably by transforming food systems through sustainable finance, competition policy, and evidence-based interventions that support smallholder producers in low- and middle-income countries.
Contribution focus: Competition regulation and market concentration in food systems.
Website: www.shambacentre.org

Ursa Collective is a U.S.-based communications and campaign strategy organization working at the intersection of agrochemical corporate accountability, climate, and environmental health. It supports coalitions building narrative power to advance pesticide reform and food systems transformation.
Contribution focus: Legal strategies and litigation in agrochemical accountability.

World Forum of Fisher Peoples (WFFP) is a global social movement network established in 1997. It represents small-scale artisanal fishers and fisherfolk organizations in 52 countries and works collectively to address the challenges facing fishing communities worldwide.
Contribution focus: Impacts of agrochemicals on aquatic ecosystems and fishing communities.
Website: www.wffp-web.org

Research Lead

Taarini Chopra is a researcher and editor who works on issues at the intersection of food systems and the environment, with a particular focus on corporate power in the agri-food system and biotechnologies. She is a senior researcher and campaigner at ETC Group, coordinator of the Agtech Justice Alliance, and senior research adviser at the Canadian Biotechnology Action Network (CBAN). Research assistance provided by Ainsley Cunningham.

Writing Team

Jack Thompson is an award-winning journalist based in Dakar, Senegal, reporting for the BBC, *Financial Times*, and Associated Press. He is also a consultant, supporting think tanks, philanthropic organizations, and investors to understand and communicate food systems.

Shailendra Yashwant is an independent journalist and researcher covering forests, wildlife, and the environmental politics shaping conservation, climate policy, and land use in South Asia. He is a visiting research fellow at the Sunway Centre for Planetary Health at Sunway University, Malaysia; a senior adviser at Climate Action Network South Asia; and a steering committee member of Pesticides Action Network India.



Defining Agrochemicals

For this compendium, we define agrochemicals as synthetic agricultural inputs derived from fossil fuels, specifically focusing on petrochemical-based pesticides and synthetic nitrogen fertilizers.

Synthetic Pesticides

Pesticides include any substance or mixture of substances containing chemical or biological ingredients intended to repel, destroy, or control any pest, or regulate plant growth.[1] Organic pesticides are derived from natural sources, such as plants, minerals, or bacteria. In this compendium, we focus on synthetic pesticides, which are manufactured from fossil fuels through industrial processes. This broad category of pesticides includes herbicides, fungicides, bactericides, insecticides, and others, including rodenticides, nematicides, molluscicides, and acaricides.

GLOBAL PESTICIDE USE (2023)[6]	VOLUME (TONNES)	SHARE OF TOTAL (%)
Herbicides	2,009,099	**54**
Fungicides and bactericides	778,387	**21**
Insecticides	759,403	**20**
Other pesticides	181,538	**5**
Pesticides (total)	3,728,427	**100**

Herbicides

are intended to kill or stop the growth of undesirable plants. In addition to agriculture, they are also used in forestry and on golf courses, lawns, school campuses, public parks, and home gardens. Herbicides are separated into four categories based on how they work: amino acid inhibitors, photosynthesis inhibitors, cell division inhibitors, and growth regulators.[2]

Fungicides and bactericides

are intended to destroy or inhibit the growth of pathogenic organisms, including fungi and bacteria, in crops and during storage. These antimicrobials[i] work through various mechanisms, including disrupting cell membranes, denaturing essential proteins, inhibiting respiration, and blocking photosynthesis.[3]

Insecticides

are intended to kill or control unwanted insects. They are classified by their type and mode of action. Among them are organochlorines and carbamates that interfere with the functioning of the nervous system, and arsenicals that poison the digestive tract and shut down cellular metabolism.[4]

Other pesticides

include rodenticides, nematicides, molluscicides and acaricides, which are intended to eliminate rodents, microscopic worms, snails and slugs, and ticks and mites by disrupting their nervous system, metabolism, or physical structures through broad-spectrum toxins.[5]

i Antibiotics, which are primarily used in livestock operations, are also used as anti microbial pesticides to manage specific bacterial diseases in crops like fruit trees.

While pesticides are primarily used on land, their use in aquaculture is increasing. This includes antimicrobial pesticides that target bacteria, viruses, fungi, and algae, as well as antiparasitics used to treat infestations of sea lice.

Highly hazardous pesticides (HHPs) are a cross-cutting category of agricultural chemicals defined by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) as posing severe acute or chronic hazards to human health and ecosystems. In 2015, the United Nations Environment Programme's Fourth International Conference on Chemicals Management adopted a resolution recognizing HHPs as an issue of international concern and calling for concerted action to address them.[7]

HHPs are now included in relevant international agreements and conventions that call for their phase-out.[8]

Emerging evidence recognizes more than 50 pesticides and their breakdown products as **endocrine-disrupting chemicals**[9] linked to hormone-related cancers, reproductive disorders, birth defects, metabolic diseases, and neurodevelopmental harm,[10] with impacts observed at concentrations as low as one part per trillion—equivalent to a single drop in 20 Olympic-size swimming pools.[11]

Pesticide formulations and their manufacturing processes can also introduce **PFAS** as contaminants or intentional additives. The strong carbon-fluorine bonds of these "forever chemicals" resist environmental breakdown, leading to long-term bioaccumulation in humans and ecosystems, and compounding exposure risks alongside the pesticide compounds themselves.[12]





Synthetic Nitrogen Fertilizers

Fertilizers are substances that contain essential nutrients—primarily nitrogen (N), phosphorus (P), and potassium (K)—designed to replenish soil and boost plant growth. Organic nitrogen fertilizers are derived from natural plant, animal, and mineral by-products. This compendium focuses on synthetic nitrogen fertilizers, which account for approximately 60 percent of total fertilizer use[13] and significantly contribute to the climate crisis and other harms through both their production and use. (It's worth noting, however, that the mining, processing, and use of mineral fertilizers—including phosphorus and potassium—causes significant ecological disruption and pollution as well.)

Synthetic nitrogen fertilizer production is deeply dependent on fossil fuels. Through the Haber–Bosch process, ammonia (NH_3)—the building block of synthetic nitrogen fertilizers—is produced by combining nitrogen and hydrogen in a highly energy-intensive process.[18] While nitrogen is freely available in the atmosphere, hydrogen must be obtained from other sources, most commonly from fossil gas (methane) through steam reforming, but also from coal via gasification or from water through electrolysis. The feasibility of these hydrogen production pathways varies substantially.

Hydrogen Production Pathways — Feasibility at a Glance

TYPE	SOURCE	EMISSIONS (DURING PRODUCTION)[19]	COMMENT
Grey	Natural gas (steam methane reforming), no carbon capture	~10 to 19 kg CO_2/kg H_2	Most prevalent today. Accounts for the vast majority of current hydrogen supply.
Brown/ black	Coal gasification	~19 t CO_2/t H_2	Being phased out in regions with carbon pricing but still used where coal-fired power plants operate.
Blue	Natural gas + carbon capture and storage	~1 to 4 t CO_2/t H_2, but highly dependent on capture rate and upstream methane leakage	Marketed as "low carbon" but real-world performance varies widely. Some analysts argue it primarily functions to extend fossil gas demand rather than displace it, since capture rates in practice often fall well below stated targets.[20]
Green	Water electrolysis powered by renewable electricity	Near-zero at point of production	Extremely energy intensive (~55 kWh/kg H_2)[21] and only low carbon when production is powered by renewable electricity. Currently accounts for 0.4 percent of global hydrogen supply.[22] Scalability is constrained by renewable electricity requirements and can face land and water constraints.[23]

SYNTHETIC NITROGEN FERTILIZERS COME IN FOUR MAIN FORMS:

Urea
fertilizers are the most widely used due to their high nitrogen content and ease of transport. Once applied, urea converts to ammonium and then nitrate, creating risks of ammonia volatilization and nitrous oxide emissions.[14]

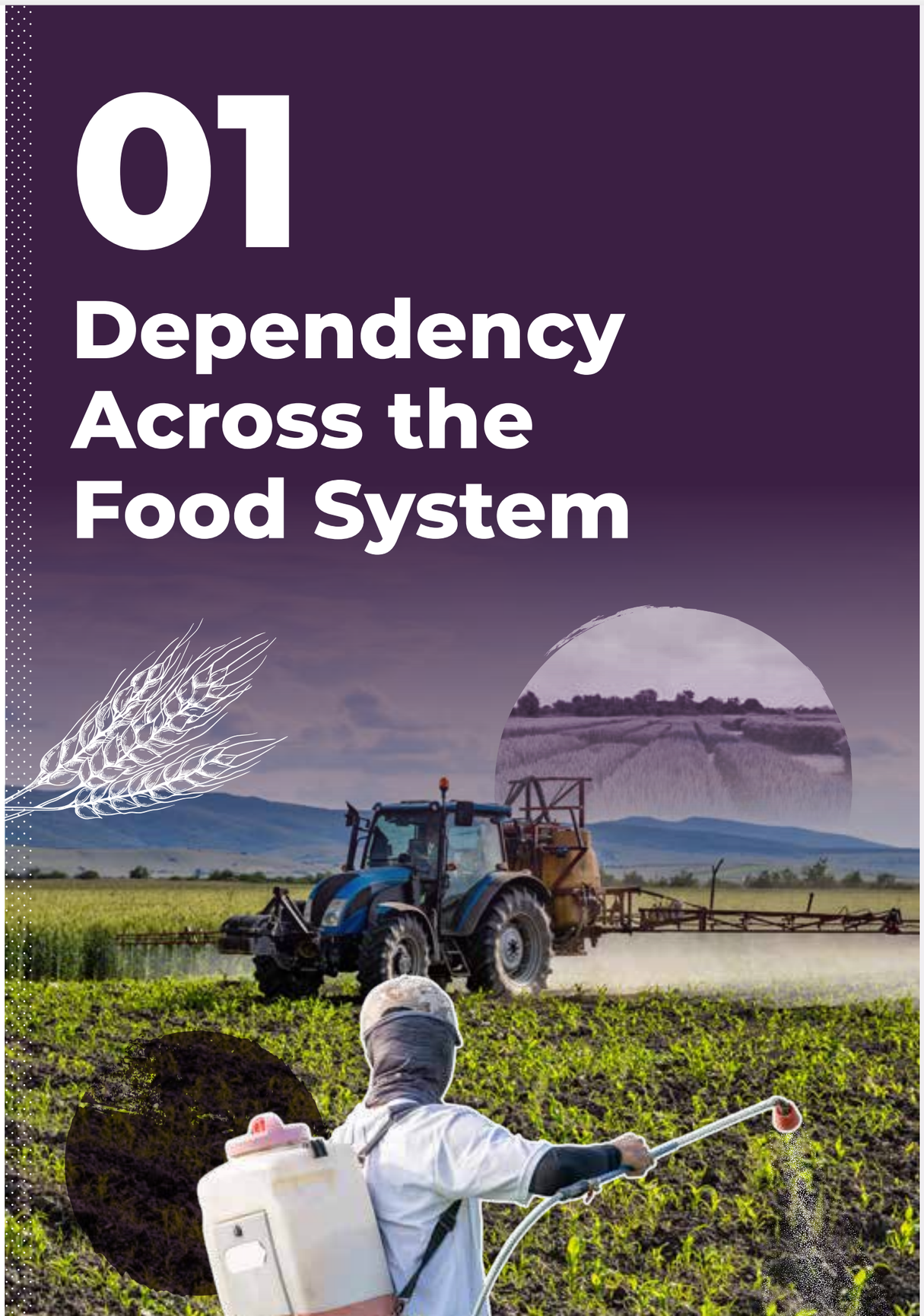
Nitrate-based
fertilizers provide nitrogen in a form immediately available to plants, supporting rapid growth; however, they are highly prone to leaching and runoff, contributing to water pollution and eutrophication.[15]

Ammonium-based
fertilizers supply nitrogen in ammonium form, which binds to soil particles and is readily taken up by plants; however, they can acidify soils and convert to nitrate through microbial processes.[16]

Anhydrous ammonia
is a highly concentrated nitrogen fertilizer injected into soil, where it reacts with moisture to form ammonium. Although it is an effective source of nitrogen, it is hazardous to handle and can contribute to soil acidification and nitrous oxide emissions.[17]

01

Dependency Across the Food System



Fossil fuel–derived pesticides and synthetic fertilizers sit at the centre of a web of interconnected crises: climate emergencies, biodiversity collapse, chronic disease, and farmer poverty. Whatever the entry point for food systems transformation, addressing agrochemical dependency—whether by reducing their use or phasing them out—will catalyze the systemic changes needed to improve food security, health, and environmental outcomes.

Increasingly pervasive agrochemical use around the world is the result of a century-long shift to fossil fuel–based food systems that began in the post-war period of industrial development across North America and Europe. In the 1950s and 60s, this model of agriculture and industrial food systems expanded exponentially with the promotion of a suite of agricultural interventions that encouraged monoculture farming using hybrid seeds whose "vigour" depends on pesticides, synthetic fertilizer, and irrigation. This high-input agricultural model uses massive amounts of agrochemicals to sustain monocultures of commodity crops. Today, the majority of commodity crops are used for animal feed, ultra-processed food ingredients, biofuels, and industrial applications.[24] Together, these inputs, commodities, and products form a tightly linked supply-and-demand system that reinforces agrochemical use and fossil fuel dependence.

The Links Between Fossil Fuels and Agrochemicals

Fossil fuels underpin agrochemical-dependent food systems both as an energy source and as a material feedstock. This dependence operates at a significant scale. Food systems account for at least 15 percent of global fossil fuel use.[25] Oil, gas, and coal are used as energy sources and feedstocks to produce key agricultural inputs, including fertilizers and pesticides.

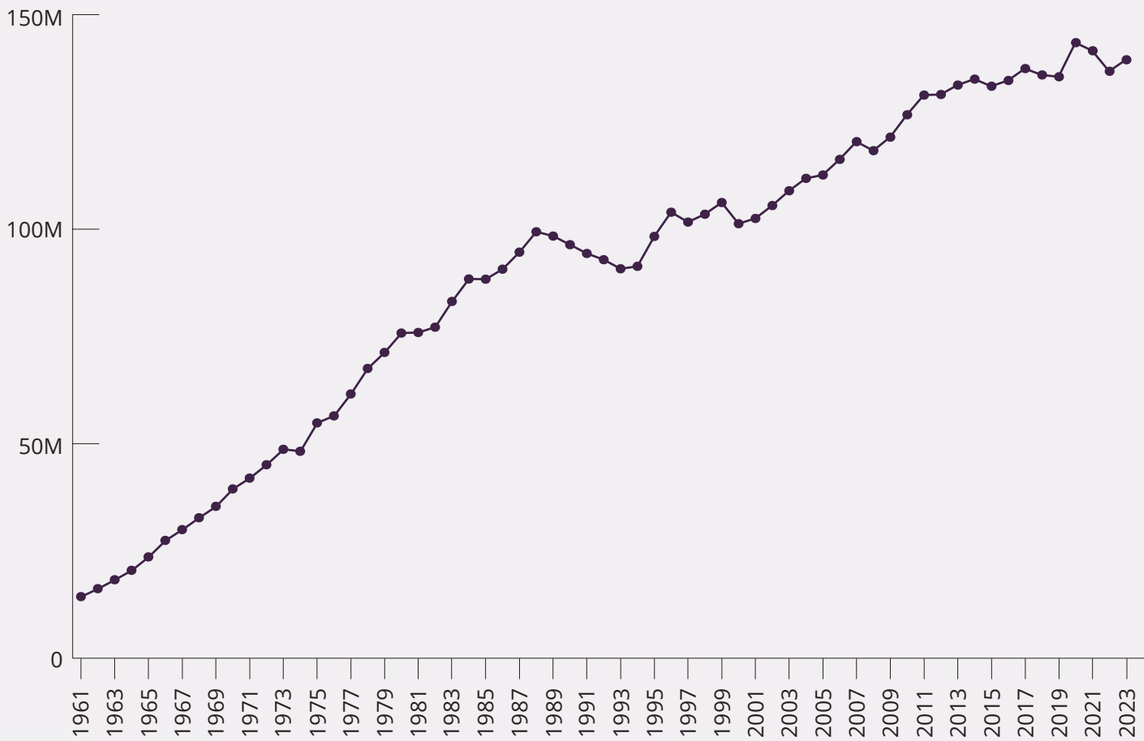
Ammonia production, which supplies the building block for nitrogen fertilizers, accounts for approximately 3 to 5 percent of global fossil gas consumption and around 4 percent of global coal consumption.[26] While coal use is decreasing in the energy and transport sectors, there is evidence coal is being redirected into chemical plants. The 2025 Global Coal Exit List identifies 47 new coal chemical projects worldwide.[27] The 2026 US–Israel war in Iran, which has greatly disrupted the supply of fossil gas needed for fertilizer manufacturing, is driving an increase in the proportion of coal being used.[28] Pacific Environment, our contributor from China, emphasized that the country's synthetic ammonia production, which has the largest capacity globally,[29] is predominantly coal-based.[30] With global supply now constrained, China is seeing increased demand, and recent policies limiting the growth of coal-based production in the country are at risk. Another troubling trend is the development and expansion of coal-to-chemical facilities in several of the world's major coal-producing countries. In this process, solid coal is transformed into liquid or gaseous chemicals—such as urea, ammonia, methanol, and olefins—with coal gasification typically serving as the first step.[31]

Despite these direct links between fossil fuels and food production, agrochemicals remain largely overlooked in climate and energy policy debates.[32] Contributor IPES-Food suggests that this can be attributed, in part, to the complexity and opacity of chemical supply chains, which allow industry to intentionally obscure the scale of fossil fuel dependence embedded in food.

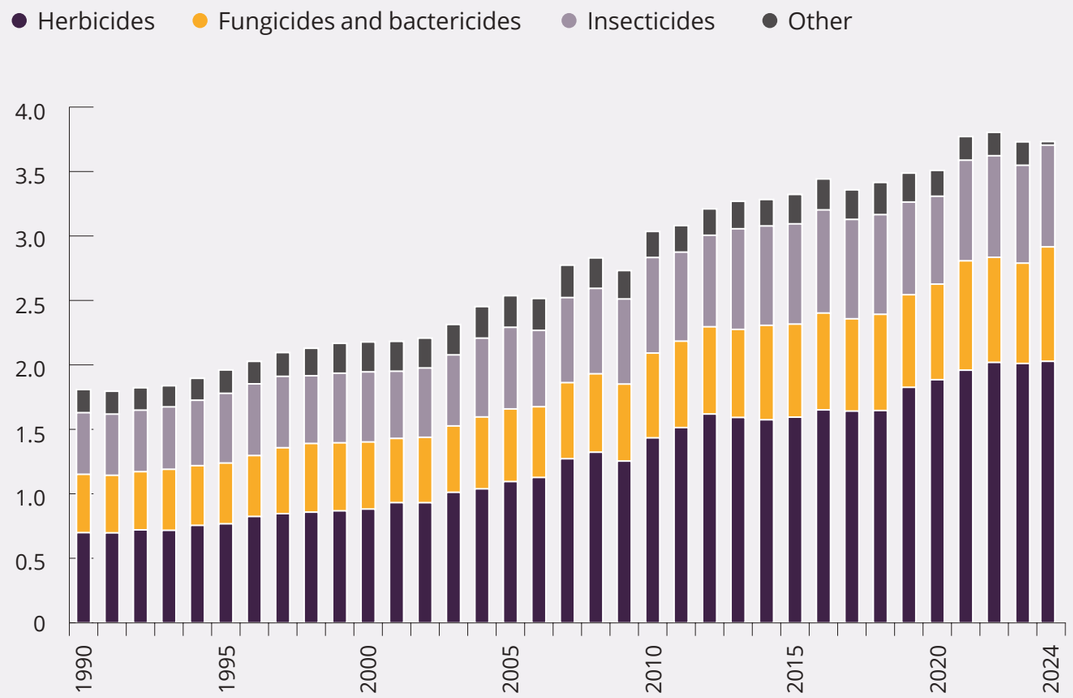
Expanding Demand in Industrial Food Systems

The use of agrochemicals has increased steadily since the FAO started tracking. According to the FAO, global use of nitrogen fertilizers has grown eightfold since the 1960s, to over 111 million tonnes in 2023,[33] and is predicted to grow by another 50 percent by 2050, driven in part by efforts to expand sales in regions like Sub-Saharan Africa, where current use remains relatively low.[34] Global pesticide use has more than doubled since 1990, with 3.92 million tonnes of active ingredient used in 2023.[35] Of this, herbicides make up the majority of that usage, largely because of the growth in the market for glyphosate.

Global Nitrogen Fertilizer Use (1961–2024, million tonnes)[38]

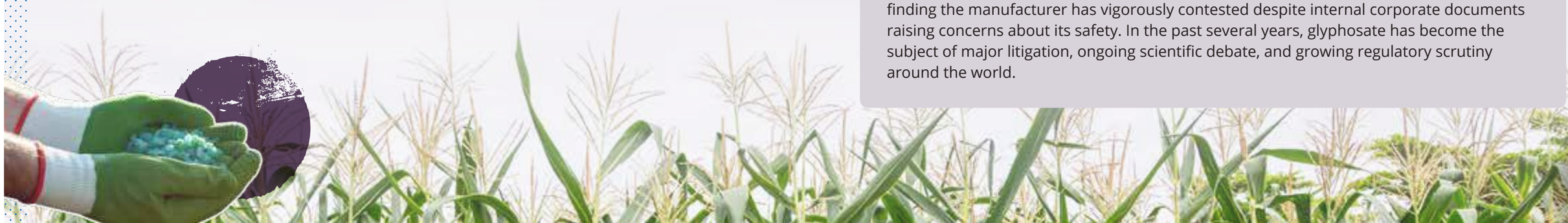


Global Pesticide Use (1990–2024, million tonnes)[39]



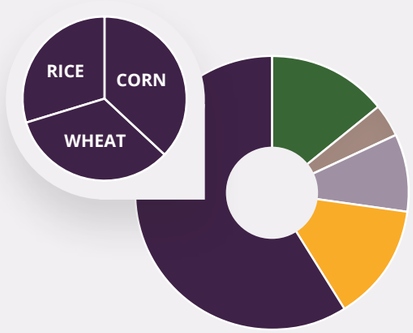
GLYPHOSATE: THE WORLD'S MOST WIDELY USED HERBICIDE

Glyphosate, which is made from mined phosphate and the amino acid glycine, is used in crop production to eliminate unwanted plants competing with crops for nutrients and space. It is also used as a desiccant, sprayed directly on crops to speed up the pre-harvest drying processor, and as a "burndown" herbicide, to clear a field before planting. Originally developed by Monsanto scientists for its weedkilling properties, it was patented by the company to be used in agriculture in the early 1970s and sold under the brand name Roundup.[36] Glyphosate became dominant after Monsanto patented genetically engineered "Roundup Ready" crops to survive it, allowing farmers to spray entire fields without harming their crops. Today, it is applied across hundreds of millions of hectares worldwide, particularly on commodity crops like soy and corn. In 2015, the World Health Organization's cancer research agency classified it as a probable human carcinogen[37]—a finding the manufacturer has vigorously contested despite internal corporate documents raising concerns about its safety. In the past several years, glyphosate has become the subject of major litigation, ongoing scientific debate, and growing regulatory scrutiny around the world.



Synthetic nitrogen fertilizers and pesticides underpin intensive industrial agriculture systems that prioritize high yields of a narrow set of standardized crops. More than half of the world's nitrogen and 35 percent of the world's pesticide is used on three primary cereal crops (corn, wheat, and rice).[40]

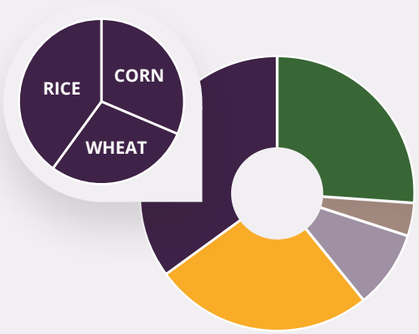
Global Synthetic Nitrogen Fertilizer Use by Crop (%)[41]



- Corn **(20%)**
- Wheat **(18%)**
- Rice **(16%)**

- Cereals **(59%)**
- Fruit & vegetables **(14%)**
- Sugar crops **(4%)**
- Oil crops **(9%)**
- Other crops, including fibre crops **(14%)**

Global Pesticide Use by Crop (%)[42]



- Corn **(11%)**
- Wheat **(10%)**
- Rice **(14%)**

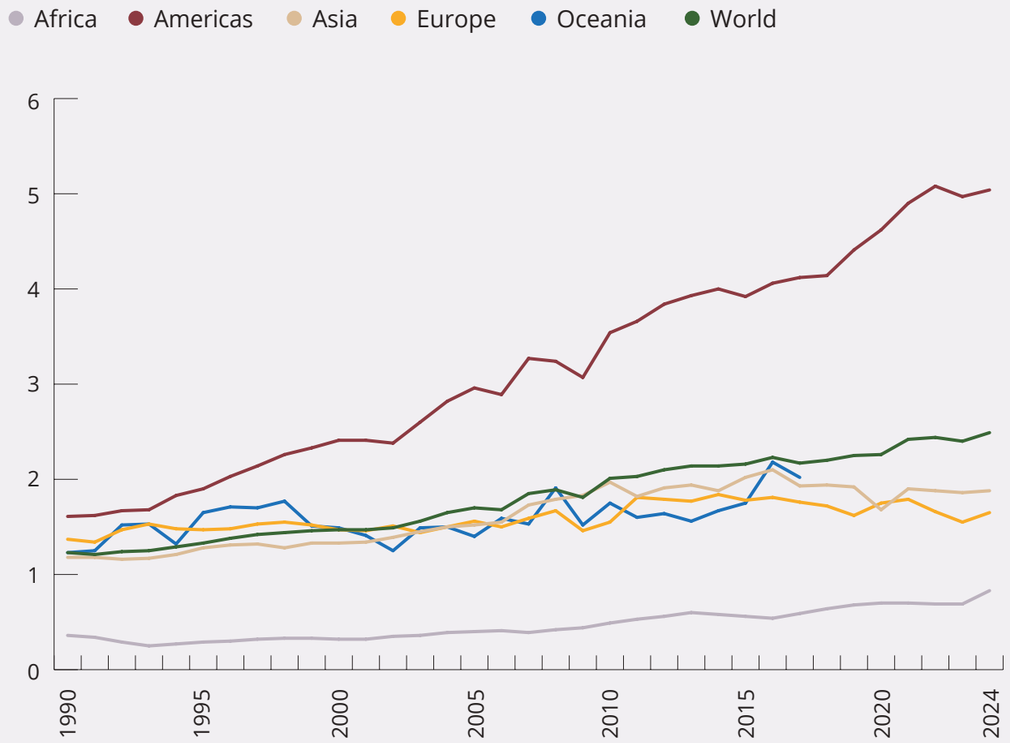
- Cereals **(35%)**
- Fruit & vegetables **(26%)**
- Sugar crops **(4%)**
- Oil crops **(9%)**
- Other crops, including fibre crops **(26%)**

Agrochemical-intensive food systems drive the production of uniform, storable commodities that move easily through global supply chains. Globally, around 90 percent of caloric intake comes from just 15 crop species,[43] reflecting a system oriented toward throughput and profit rather than nourishment, sustainability, or resilience. These crops increasingly serve industrial rather than direct food uses: 40 percent of crop-produced calories go to livestock feed, and a further 15 percent to industrial uses and biofuels, leaving only about half of all calories produced on cropland available for direct human consumption.[44]

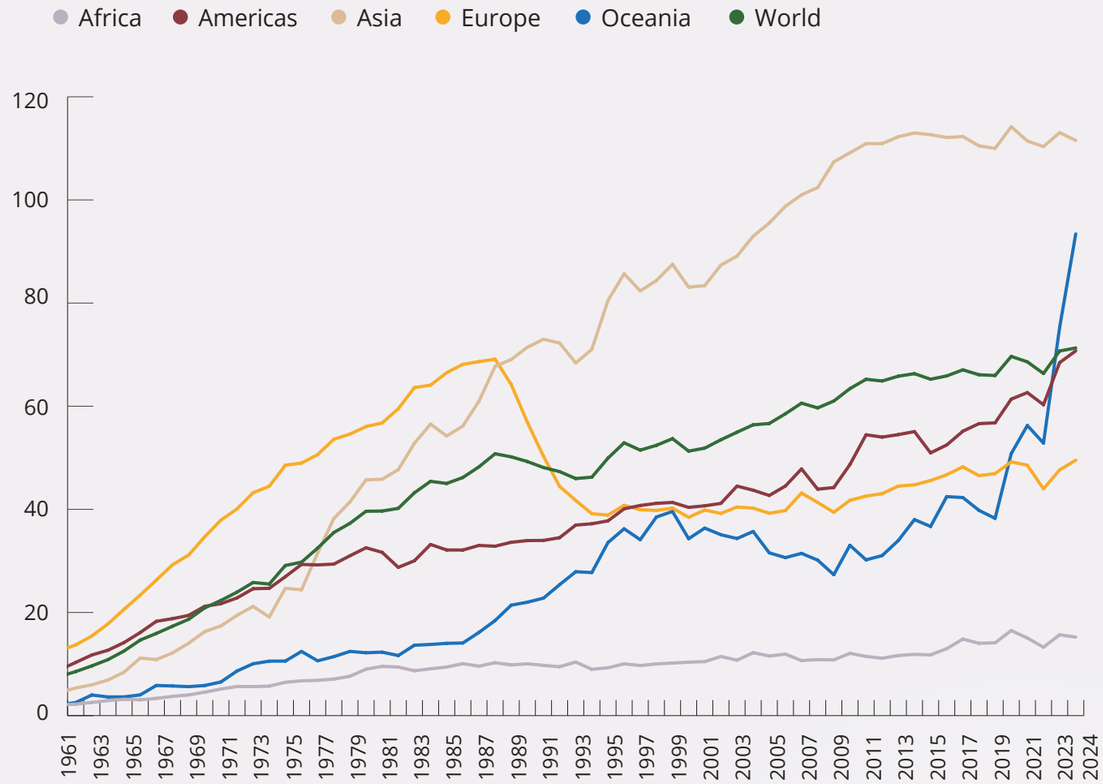
In the United States, this system now translates directly into diets, with ultra-processed foods accounting for 55 percent of total caloric intake and nearly 62 percent among children and youth.[45]

Uniform, storable commodities—and the fertilizers and pesticides used to grow them at scale—simultaneously fuel industrial livestock expansion, ultra-processed food manufacturing, and biofuel production, with the balance among these three uses varying significantly by region depending on national mandates, subsidies, and trade policy, as well as the total quantities of fertilizer and pesticide use per area of cropland.

Pesticide Use per Area of Cropland by Region (1990–2023, kg/ha)[46]

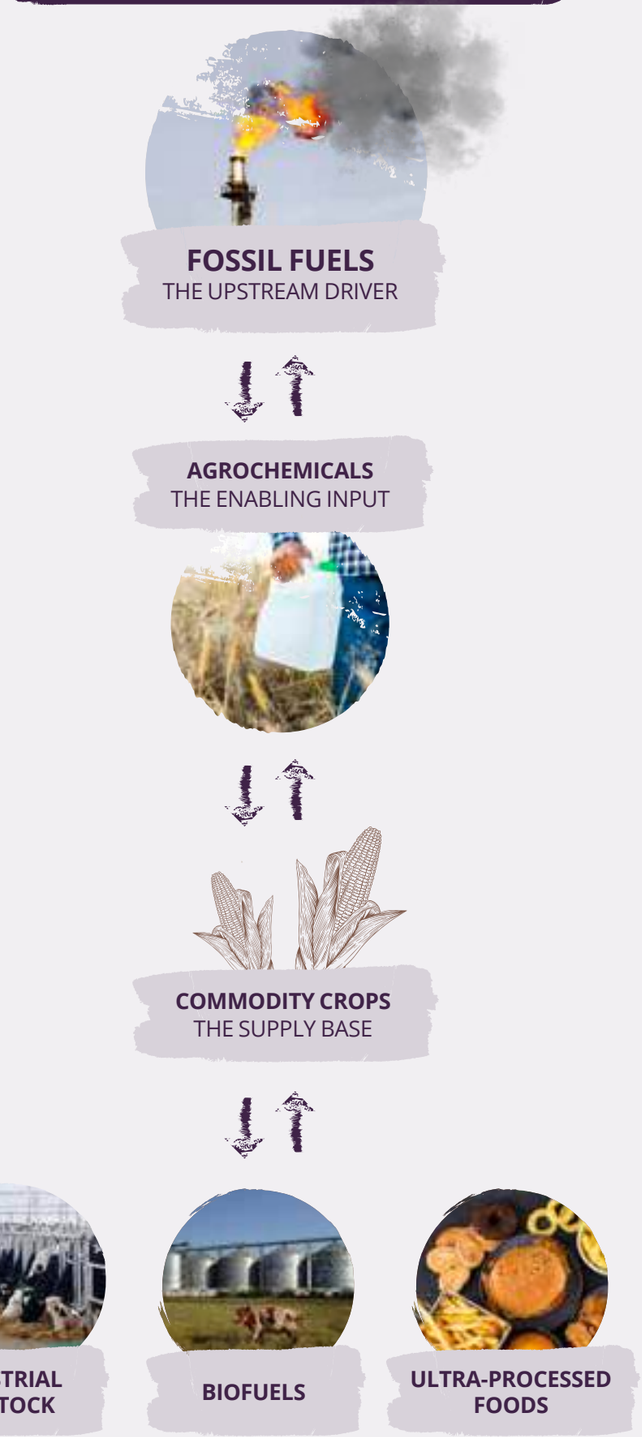


Synthetic Nitrogen Fertilizer Use per Area of Cropland by Region (1961–2024, kg/ha)[47]





SUPPLY AND DEMAND LOOP



Industrial meat and dairy A continuous supply of commodity crops for animal feed enables industrial-scale livestock production,[48] which in turn generates large volumes of animal waste, including methane emissions,[49] one of the most significant contributions to climate change,[50] alongside nutrient runoff, water contamination, and ammonia release.[51]

The global food system devotes an extraordinary share of its land, inputs, and environmental burden to producing meat and dairy, yet these products contribute a disproportionately small share of human nutrition. The most comprehensive meta-analysis of global food systems to date, covering 38,700 farms across 119 countries, found that 83 percent of all agricultural land is used for livestock production, yet meat and dairy together supply only 18 percent of global calories and 37 percent of global protein consumed by humans.[52]

Central to this dynamic are two crops that together dominate global arable agriculture: corn and soy. Both are cultivated at a vast scale in extensive monocultures, and both are overwhelmingly destined not for human plates but for livestock feed. Globally, 40 percent of all crop calories are diverted to animal feed, with corn, soy, and oilseed meal among the dominant contributors, yet only 12 percent of those feed calories ultimately return to the human diet as meat and animal products.[53] Globally, 56 percent of all corn and 77 percent of all soy is grown to feed animals rather than people.[54] Together, corn and soy cultivation for livestock accounts for more than 13.3 percent of all pesticides and 12.7 percent of synthetic nitrogen applied worldwide.[55]

While total calorie production is increasing, the number of calories available for human consumption is not keeping pace, indicating that croplands are being used less efficiently to feed people.[56]

This intensive livestock model also drives antimicrobial resistance (AMR): Globally, an estimated 73 percent of all antimicrobials are used in animals raised for food, a practice strongly linked to elevated rates of resistant pathogens in both animals and humans.[57]

Ultra-processed foods (UPFs) The same fossil fuel–dependent commodity crops driving industrial livestock production also supply the raw material for UPF manufacturing.[58] These crops are fractionated into starches, oils, sweeteners, and protein isolates, which are then reassembled into the building blocks of processed products. Ultra-processed animal products (UPAs)—reconstituted meat items such as hot dogs and chicken nuggets—compound this problem, driving additional agricultural biodiversity loss. These products typically rely on a small number of high-yielding livestock breeds, raised in confinement and fed concentrates made from the same handful of commodity crops used in plant-based UPF manufacturing.[59] The result is a feedback loop: a narrowing pool of crop and animal genetics feeding an expanding pool of UPF and UPA products.

Using a machine-learning model trained on USDA nutrient data, researchers at Northeastern University found that over 73 percent of the U.S. food supply meets the criteria for ultra-processing, and that higher dietary reliance on these foods is associated with increased risk of metabolic syndrome, diabetes, and elevated blood pressure.[60]

UPFs are engineered to override natural appetite cues, driving compulsive overeating. They displace whole foods, fuelling a surge in chronic, non-communicable diseases.[61]

Biofuels Commodity crops—particularly corn, one of the highest users of synthetic nitrogen fertilizer[62]—are increasingly diverted to biofuels. Incentives for biofuels, including renewable fuel standards, tax credits, and subsidies, drive the over-production of these crops. Biofuel demand reinforces rather than replaces agrochemical-intensive supply chains, complicating the case made for biofuels as a sustainable alternative to fossil fuels.[63]

Land-use efficiency is one point of comparison: If the 32 million hectares of land currently used to produce biofuels were instead used for solar panel installation, they would generate around 32,000 terawatt-hours (TWh) of electricity annually—roughly equivalent to the amount of global electricity generated in 2024 and about 23 times more energy than the biofuels currently produced on that same land (1,400 TWh).[64]

Biofuels also reduce the net availability of food globally, with human-edible calories used for biofuel production increasing fourfold between the 2000 and 2010, from 1 percent to 4 percent.[65]

> Growth in industrial meat and dairy, UPF, and biofuels, sustain and increase the demand for commodity crops, creating a self-reinforcing cycle that leads to the increasing use of agrochemicals despite well-documented environmental, health, and social harms. These industrial food systems remain tightly coupled to fossil fuel–dependent inputs.

02

Assessing the Risks and Impacts



Agrochemical-dependent food systems generate far-reaching environmental, health, social, and economic harms that extend well beyond the fields and waterways where these inputs are applied. Evidence compiled from our contributors and the literature paints a clear picture of the staggering environmental, health, and social impacts and systemic harm caused by agrochemicals. Our assessment of these impacts shows how these harms are not merely a result or outcome of agrochemical-dependent systems; the harms actively reinforce and lock in agrochemical dependency.

Environmental, Health, Social and Economic Impacts

Pesticides and synthetic nitrogen fertilizers circulate through ecosystems, food chains, and human bodies, contaminating air, water, and soil while reshaping the ecological processes that sustain life itself. Many of these chemicals spread beyond their intended targets, bioaccumulate in living organisms, and interact in complex mixtures. Additionally, while pesticide regulation is almost entirely based on the assessment of individual chemical ingredients, real-world exposure involves formulations that combine multiple chemicals. Long-term animal studies have found that mixtures of pesticides and other food-borne chemicals can produce organ-level effects even at doses below the regulatory "safe" threshold for any single compound.[66] This is a persistent regulatory gap, as current risk-assessment frameworks are not well-equipped to capture the cumulative effects of the chemical cocktails that organisms, including humans, are actually exposed to. Efforts to tighten regulation of agrochemical formulations are emerging in regions such as the EU but face challenges, including heavy reliance on unpublished industry-produced studies.[67]

A NOTE ON EVIDENCE

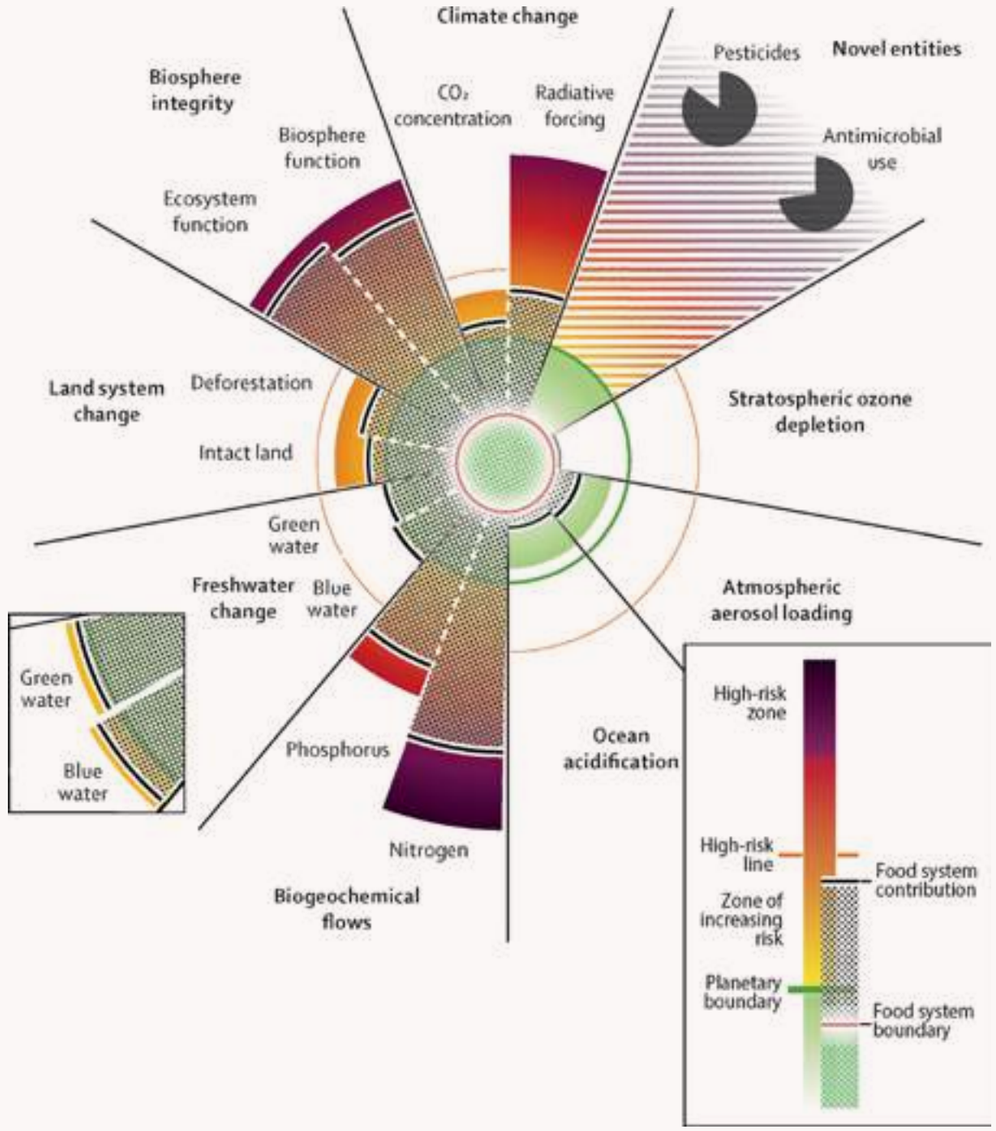
Given the toxic nature of agrochemicals, intentional human exposure for research purposes violates ethical standards, and most existing evidence comes from observational and epidemiological studies. Despite the slower pace of these methods, decades of research, including long-running longitudinal birth cohort studies,[68] have produced a consistent body of evidence linking agrochemical exposure to environmental degradation, human health impacts, and broader social and economic disruption.

Another challenge for documenting the impacts of agrochemicals is that companies are not required to disclose all of the chemicals used in proprietary formulations. This results in a focus on individual chemicals in research and in regulation that fails to account for the cumulative, additive, and synergistic toxic effects of complex mixtures and repeated exposures, to which farmers, communities, and ecosystems are exposed in real-world contexts.[69]

Environmental harms

Food systems are the primary driver of the breach of five of the nine planetary boundaries that define the safe operating limits for humanity on Earth.[70] Agrochemicals are major contributors to this disruption, contaminating water resources and altering global nitrogen and phosphorus cycles,[71] which destabilizes the ecological foundations upon which food production depends. These environmental disruptions translate directly into human health and societal impacts, increasing vulnerability in a changing climate.

Global Food System Impacts Across the Nine Planetary Boundaries[72]



Health harms

Exposure to agrochemicals through occupational contact, environmental contamination, and residues in food—whether chronic and cumulative, or acute—has been associated with a wide range of negative health outcomes, from respiratory illness and neurological disorders to cancers, endocrine disruption, chronic kidney disease, reproductive harms, and dermatologic conditions. The risk and impacts of exposure are highest among those who manufacture and/or apply agrochemicals, as well as those living near farmland and production facilities. However, everyone is affected worldwide—a phenomenon of invisible impacts from global food systems that experts have called a "silent pandemic."[73]

Social and economic harms

Beyond health, agrochemical-dependent food systems erode farmer and fisher autonomy and displace locally adapted knowledge through a reliance on purchased and proprietary inputs such as seeds and synthetic fertilizers and pesticides. These pressures are compounded by industrial food systems that reshape rural economies, accelerate land concentration and monoculture expansion, destabilize ecological systems, and displace local food cultures, all of which leave communities more vulnerable to environmental and economic shocks.

Ultimately, these environmental, health, and social harms do not merely result from agrochemical-dependent systems; they actively reinforce them through feedback loops that drive greater input use and narrow the space for transitions to agroecological models. Environmental degradation creates challenges for agricultural productivity, requiring greater input use; health harms are managed downstream through healthcare systems (if care is accessible); and social and economic pressures reduce the capacity of farmers and communities to exit the chemical-intensive treadmill.

This synthesis of evidence reveals that agrochemicals do not simply function as food production inputs; they operate as system-shaping forces that damage ecosystems, bodies, and societies.



Environmental Impacts: How agrochemicals destabilize ecological systems and undermine resilience

> *Pesticides can persist in the environment for decades and pose a global threat to the entire ecological system upon which food production depends. Excessive use and misuse of pesticides result in contamination of surrounding soil and water sources, causing loss of biodiversity, destroying beneficial insect populations that act as natural enemies of pests and reducing the nutritional value of food.*
>
> **—2017 Special Rapporteur on the Right to Food[74]**



Fertilizer production consumes **3 to 5%** of global fossil gas and **4%** of the world's coal

Evidence provided by contributors demonstrates that agrochemical dependence substitutes chemical inputs for ecological processes, destabilizing soils, water systems, biodiversity, and climate dynamics. Widespread agrochemical use disrupts soil biology, pollinators, and food webs, undermining the ecological functions that sustain productive and resilient ecosystems. Agrochemicals enter ecosystems through spray drift, runoff into water bodies, groundwater contamination, and atmospheric transport, where they accumulate in soils, waterways, wildlife, and food chains. These impacts intensify reliance on external inputs, including irrigation, weaken ecosystem resilience, and increase vulnerability to climate shocks.

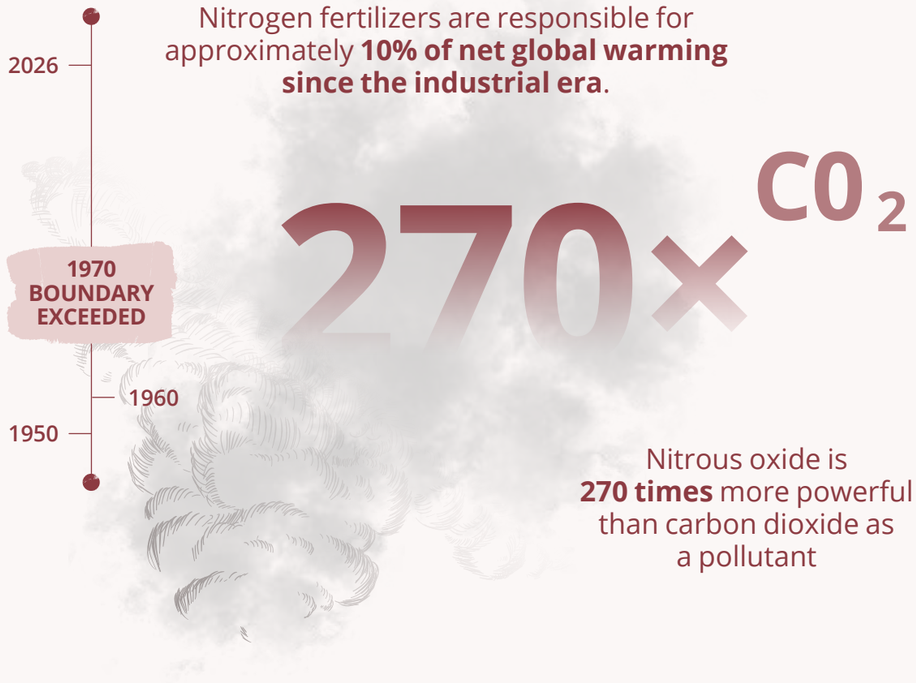
Air, water, soil pollution

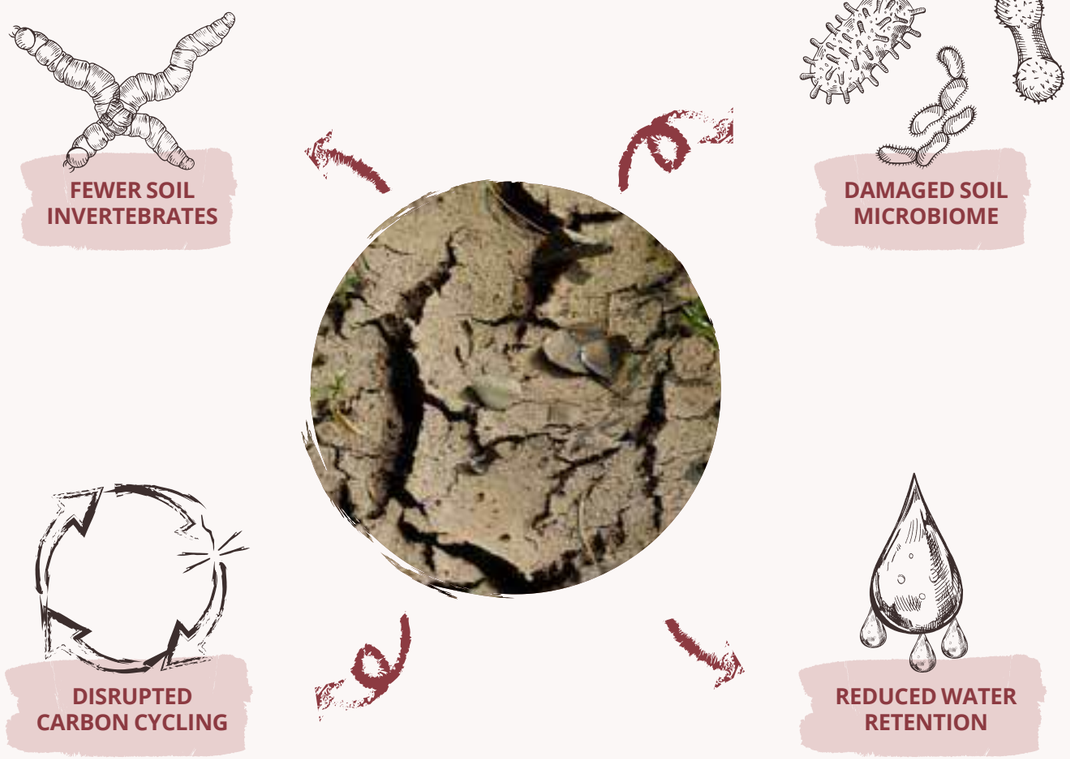
The FAO calculates the environmental costs of nitrogen emissions at the primary production level—including ammonia and nitrogen oxide emissions to air, nitrogen runoff, and leaching, as well as sewage—to be more than USD 1.45 trillion annually.[75] Greenhouse gas emissions across the entire food value chain, from food and fertilizer production to energy use, contribute an additional USD 1.26 trillion.

These dynamics ripple across climate, soil, water, and biodiversity systems. Fertilizer production consumes 3 to 5 percent of global fossil gas and 5 percent of the world's coal, while nitrogen fertilizers and their associated emissions account for roughly 4 percent of global greenhouse gas emissions.[76]

Nitrous oxide and the climate crisis

Nitrous oxide is approximately 270 times more potent than carbon dioxide,[77] and fertilizer-related N_2O emissions account for about 10 percent of net global warming since the industrial era,[78] pushing the planet beyond safe ecological limits. The planetary boundary for nitrogen was breached as far back as 1970.[79] More than half of all applied nitrogen fertilizer is lost to the environment,[80] contributing to pollution across terrestrial and aquatic ecosystems.





Two-thirds of agricultural land worldwide is at risk of pesticide pollution

Degraded soil

Nearly two-thirds of agricultural land worldwide is at risk of pesticide pollution from more than one active ingredient.[81] Pesticides contribute to climate change throughout their lifecycle—from manufacturing and transport to application, environmental degradation, and disposal.[82] Some fumigant pesticides have been shown to increase nitrous oxide production in soils by up to eightfold.[83]

Other pesticides contribute to ground-level ozone formation, while pesticide compounds such as sulfuryl fluoride are themselves powerful greenhouse gases with nearly 5,000 times the warming potential of carbon dioxide.

These pressures degrade the very foundations of agricultural productivity. Synthetic fertilizers and pesticides damage soil microbiota, structure, and carbon cycling, while pesticides pose clear hazards to soil invertebrates that maintain fertility and water retention.[84] Agrochemicals disrupt microbial communities and kill beneficial organisms responsible for soil structure, water retention, pH regulation, nutrient cycling, and carbon storage processes.[85]

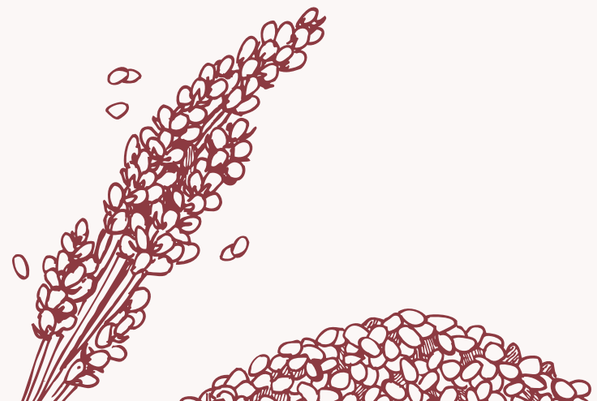
Chemical dependence

As soil health declines, agricultural productivity becomes increasingly dependent on external inputs. Greater quantities of fertilizer and increasingly toxic pesticides are often required to sustain yields, reinforcing cycles of chemical dependence. Glyphosate use, for example, has contributed to the emergence of 62 glyphosate-resistant “superweed” species globally,[86] leading to reliance on additional and more toxic chemicals.



Biodiversity loss

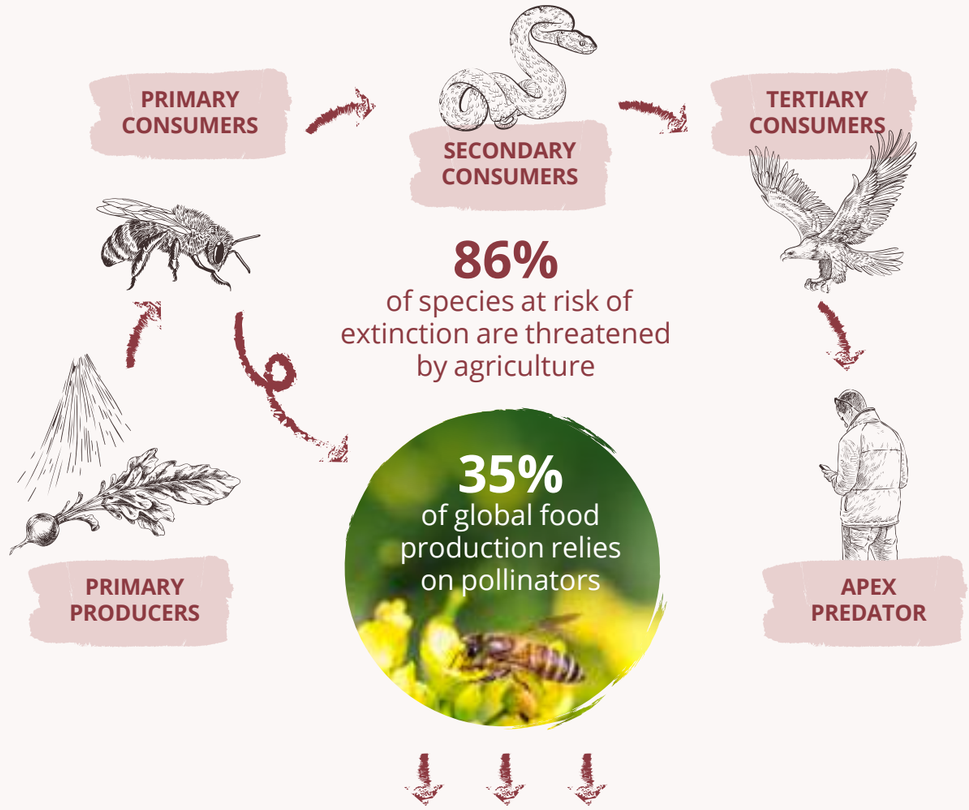
The consequences extend throughout ecosystems. Pesticide exposure harms species across all trophic levels.[87] While pesticides are intended to eliminate specific pests, they also cause widespread harm to non-target plants, animals, and microorganisms.[88] Antimicrobial pesticides, including antibacterial compounds used in livestock and aquaculture systems, affect microorganisms that underpin ecosystem functioning.[89]



Pollinator collapse

Pollinator and beneficial insect populations decline as agrochemical use intensifies. Insects are essential to ecosystem functioning, and pollinators such as bees and butterflies affect 35 percent of global food production and are essential for nearly 75 percent of the crops that produce fruits and seeds for human consumption.[90] Pollinators are in sharp decline due to pesticide exposure, while fertilizer use has also been linked to reduced pollinator populations. Global insect biomass has declined by an estimated 2.5 percent per year over the past three decades,[91] a decline that may lead to the extinction of 40 percent of the world's insect species over the next few decades,[92] threatening the ecological functions insects provide.

Agriculture is the leading cause of biodiversity loss worldwide and threatens 86 percent of species at risk of extinction.[93]



Wildlife decline

Pesticide exposure disrupts growth, reproduction, behaviour, metabolism, and physiological processes across a wide range of organisms, including amphibians, reptiles, fish, birds, mammals, and invertebrates. Exposure can also alter DNA regulation and expression, creating effects that may persist across multiple generations.[94] Wildlife populations are also affected. Agrochemicals affect bird embryos, eggshell structure, growth, and appetite, while reducing insect food sources and shrub habitats needed for survival.[95] Pesticide exposure is implicated in farmland bird declines globally, including population decreases of 60 percent in the United Kingdom, 74 percent in North America,[96] and 39 percent in India.[97]



More than **400 ocean dead zones** now exist worldwide, totalling more than **245,000 km²**

Only **50%** of nitrogen fertilizer stays on the farm

Aquatic ecosystems

Aquatic ecosystems are also under increasing pressure. Nitrogen runoff into lakes and oceans fuels harmful algal blooms that create hypoxic (low oxygen) "dead zones." Research from 2025 identified more than 500 ocean dead zones worldwide, collectively spanning over 4.5 million km²[98]—an area larger than the European Union.

Wetlands are particularly vulnerable, with 22 percent lost since 1970, and agrochemicals are a major driver of this degradation.[99] Pesticides inhibit growth, photosynthesis, and biochemical activity of cyanobacteria that naturally fertilize wetland crops such as rice.[100]

Fungicides, for instance, have been found to increase mortality among amphibians, gastropods, zooplankton, algae, and aquatic plants, reducing biodiversity, decomposition processes, nutrient cycling, and water clarity.[101]

> Agrochemicals ultimately undermine the ecological foundations on which agricultural productivity depends. By replacing natural processes with external chemical inputs, they create cycles of dependency that degrade soils, destabilize ecosystems, and reduce resilience to climate and environmental shocks. Restoring agricultural resilience requires rebuilding the biological systems that sustain fertility, biodiversity, and long-term productivity.

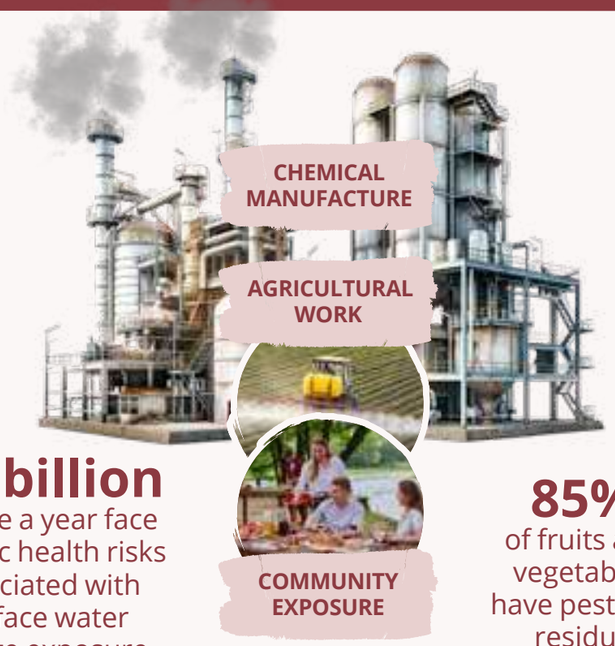


Health Impacts: How agrochemicals disrupt vital biological functions

Agrochemical-intensive food systems result in widespread human exposure to synthetic chemicals through workplaces, environments, and diets. In 2025, researchers at Systemiq estimated that pesticide exposure imposes global human health costs of USD 816 billion annually.[102] Contributors highlighted evidence of health impacts resulting from acute poisoning as well as chronic exposure and cumulative harm. Studies have shown routine, low-dose exposure to multiple agrochemicals accumulate over time and have the potential to produce additive or synergistic effects.[103] This can lead to long-term health risks that are rarely captured by single-substance or short-term safety assessments.

These impacts are widespread but unevenly distributed, disproportionately affecting farmworkers, rural and coastal communities, and people working in and living near chemical manufacturing facilities.[104] Women and children are more biologically vulnerable. Children absorb pesticides more readily than adults and have heightened vulnerability during critical developmental milestones.[105] Women are especially vulnerable during critical exposure windows—before conception, during pregnancy, and during breastfeeding—and experience inequitable occupational exposure, as they make up a large share of the global agricultural workforce.[106]

HUMAN EXPOSURE TO SYNTHETIC CHEMICALS IS WIDESPREAD



1.3 billion
people a year face chronic health risks associated with surface water nitrate exposure

85%
of fruits and vegetables have pesticide residue

Food systems generate up to **35% of global PM 2-5 pollution**

The health risks of agrochemicals begin well before fertilizers and pesticides are applied in the field. Fertilizer and pesticide production depends on fossil fuel extraction, chemical manufacturing, transport, storage, and waste management, creating exposure risks throughout the supply chain.

Exposure continues throughout agricultural production. Agricultural workers experience the highest direct exposure through mixing, spraying, harvesting, equipment cleaning, and handling treated crops. Inadequate protective equipment, unsafe storage, weak regulation, limited training, and poor access to healthcare further increase these risks.[107] Burdens also fall disproportionately on communities near production facilities and farms.[108] Fertilizer manufacturing releases ammonia, nitrogen compounds, and other pollutants long before agrochemicals reach agricultural fields. After application, pesticides and fertilizers contaminate surrounding environments through spray drift, atmospheric transport, runoff into rivers and lakes, and groundwater contamination.

Nitrogen pollution has become one of the largest global exposure pathways associated with synthetic fertilizer use. By 2010, 1.3 billion people a year globally faced potential chronic health risks associated with surface water nitrate exposure.[109]

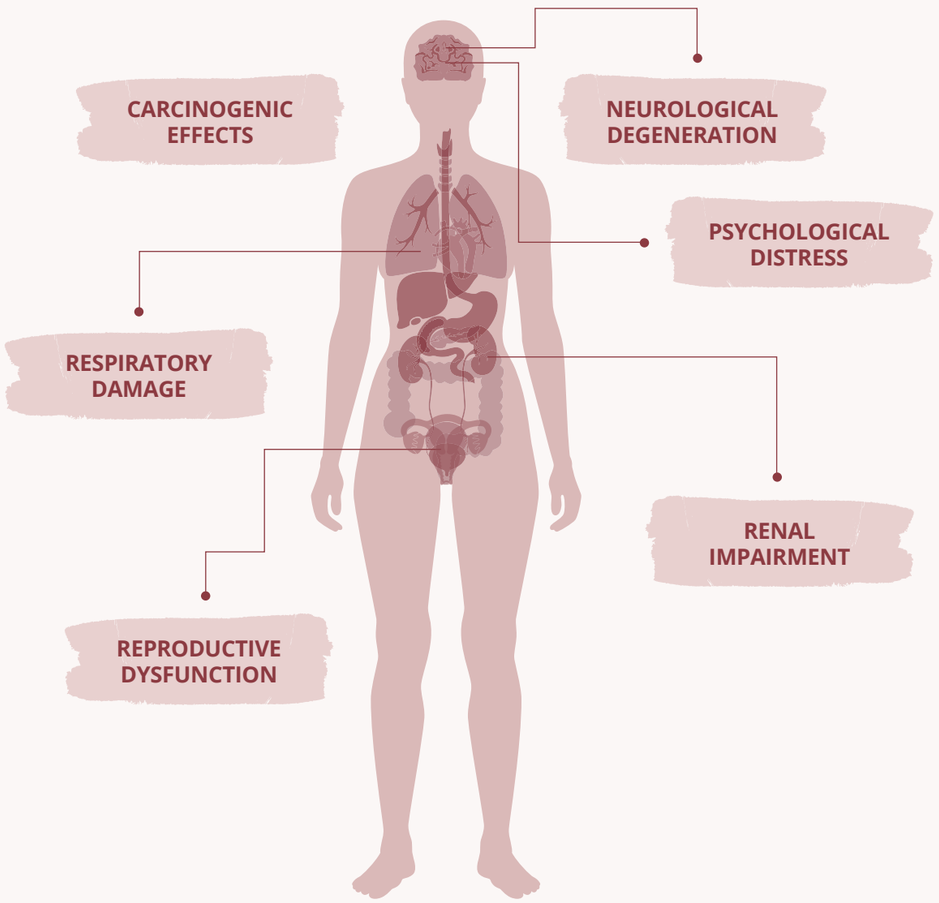
Air pollution provides another major pathway for agrochemical exposure. Nitrogen dioxide released during fertilizer production and application, together with ammonia emitted from fertilized soils, reacts in the atmosphere to form fine particulate matter ($PM_{2.5}$), which can penetrate deep into the lungs and bloodstream. A 2022 Nature Food analysis estimated that food systems generate up to 35 percent of global $PM_{2.5}$ pollution, highlighting the substantial contribution of agricultural nitrogen use to airborne particulate pollution.[110]

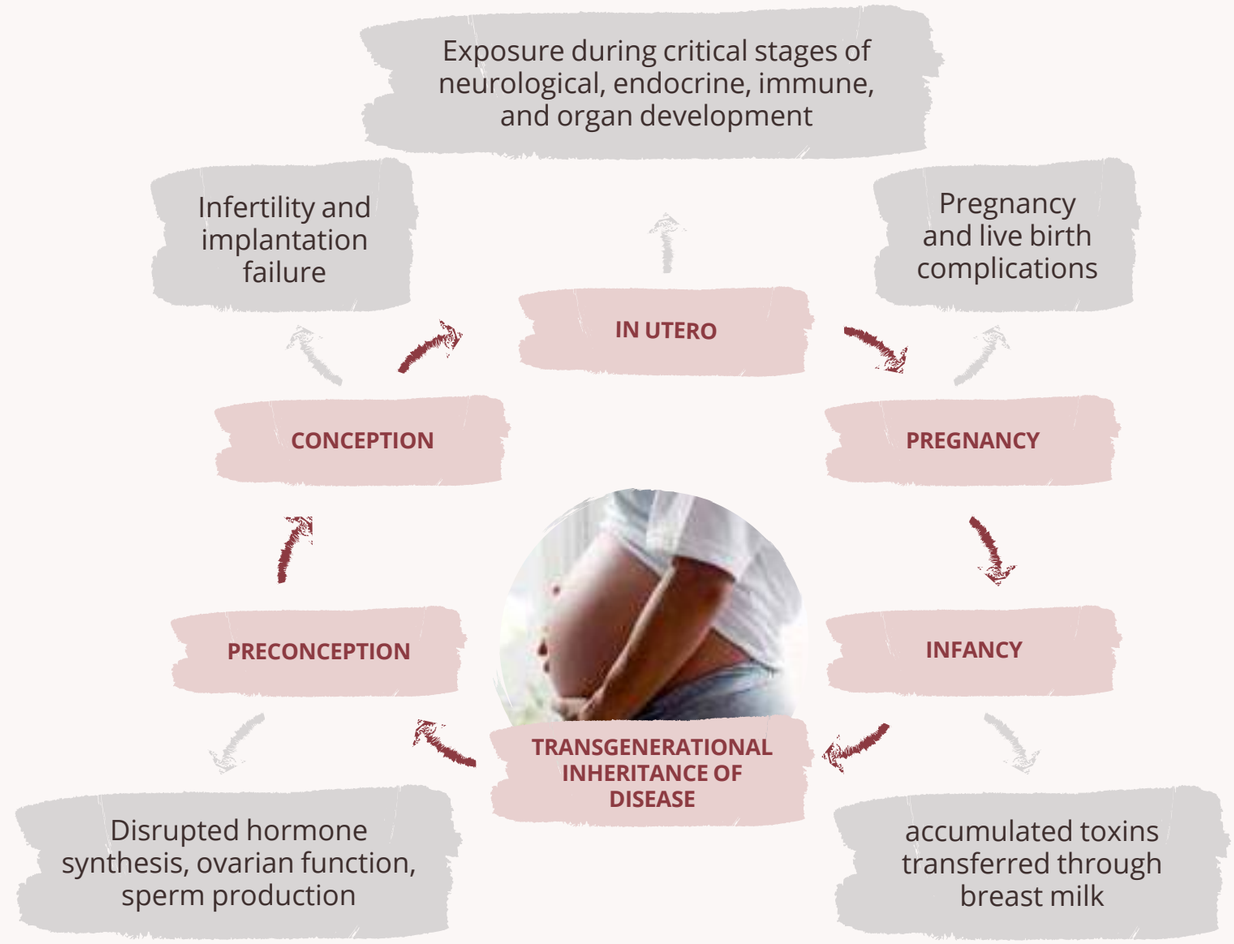
Food provides another continuous and involuntary pathway for agrochemical exposure. A systematic review of Brazilian monitoring studies identified 111 pesticide residues in fruits and vegetables across 13 states, including 16 residues exceeding legal limits.[111] A 2025 global systematic review detected pesticide residues on 85 percent of harvested fruits, berries, pulses, and leafy vegetables surveyed in Western countries.[112] Together, these findings show that agrochemical-intensive production can affect the safety of food.

Agrochemical exposure does not affect a single organ system in isolation. It disrupts endocrine signalling, neurological development, immune function, cellular metabolism, reproduction, growth, and gene expression, with consequences that emerge across multiple organ systems throughout the life course.[113]

> *Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants … By their nature, pesticides are potentially toxic to other organisms, including humans.*
>
> **—World Health Organization[114]**

HOW AGROCHEMICALS DISRUPT THE HUMAN BODY





Reproductive dysfunction

These biological disruptions have important implications for reproductive health. Research shows that pesticide exposure disrupts hormone synthesis, ovarian development, sperm production, fetal development, and fertility.[115] Reported health outcomes include menstrual disorders, premature ovarian insufficiency, polycystic ovary syndrome,[ii] infertility, implantation failure, pregnancy complications, reduced sperm concentration, and lower probabilities of pregnancy and live birth. A meta-analysis of 20 epidemiological studies found that higher pesticide exposure was consistently associated with lower sperm concentration,[116] while studies of women undergoing fertility treatment linked both occupational exposure and greater dietary exposure to pesticide residues with reduced probabilities of pregnancy and live birth.[117]

> *Children's exposure to pesticides should be limited as much as possible.*
>
> **—The American Academy of Pediatrics[118]**

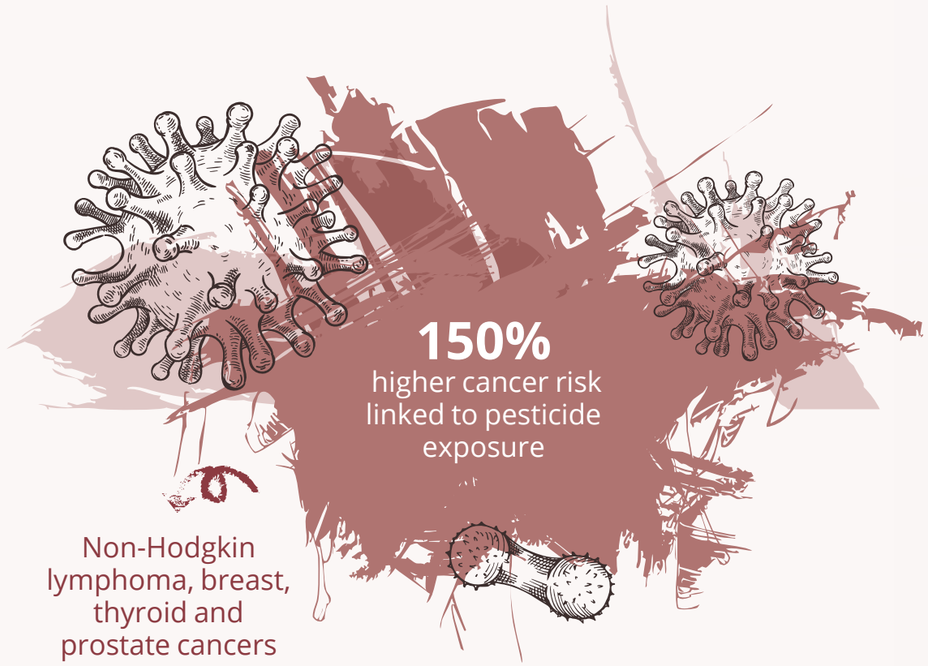
The impacts of agrochemical exposure begin before birth and continue throughout childhood. Many pesticides readily cross the placenta, exposing embryos during critical stages of neurological, endocrine, immune, and organ development.[119]

Accumulated toxins can be transferred through breast milk, creating intergenerational pathways of chemical exposure.[120] Biomonitoring studies have detected pesticide residues in umbilical cord blood,[121] demonstrating that exposure begins before birth and continues throughout infancy.

ii Now known as polyendocrine metabolic ovarian syndrome.

Pesticides have been shown to cause the epigenetic transgenerational inheritance of disease, impacting future generations even without direct exposure.[122] Children are particularly vulnerable because their brains, endocrine systems, immune systems, liver, and kidneys are still developing.[123] Compared with adults, infants and young children consume more food and water relative to their body weight, absorb pesticides more readily, and metabolize toxic substances less efficiently.

As a result, even low-dose exposures during critical developmental windows can produce lifelong health consequences. Epidemiological studies link pesticide exposure during pregnancy to neurodevelopmental disorders, impaired motor development, learning disabilities, reduced IQ, behavioural disorders, birth defects, and childhood cancers including leukemia and central nervous system tumours.[124] Long-term nitrate contamination has been linked to neural tube defects and methemoglobinemia, which leads to low blood oxygen levels, in infants.[125]



Carcinogenic effects

Growing evidence links pesticide exposure to multiple forms of cancer, including non-Hodgkin lymphoma and hormone-sensitive cancers such as breast, thyroid, and prostate cancer.[126] Long-term exposure to nitrate-contaminated drinking water has also been linked to increased cancer risks.[127]

A 2026 study of environmental pesticide mixtures reported that exposure to complex pesticide mixtures increased overall cancer risk by an average of 150 percent,[128] reinforcing concerns that conventional chemical-by-chemical risk assessments underestimate real-world exposure. A 2019 meta-analysis found that exposure to glyphosate-based herbicides increased the risk of non-Hodgkin lymphoma by 41 percent among exposed populations.[129]



Increased incidence of chronic kidney disease in agricultural communities



22%
of global air pollution mortality is attributable to food systems



80%
Higher odds of Parkinson's disease associated with pesticide exposure

50%
Higher risk of Alzheimer's disease and ALS

Renal impairment

Evidence links agrochemical exposure to chronic kidney disease in agricultural communities. Chronic Interstitial Nephritis in Agricultural Communities (CINAC) has become a major occupational health concern in Sri Lanka, Central America, and India.[130] In Sri Lanka alone, CINAC is estimated to affect more than 60,000 people and cause 20,000 deaths each year.[131] Researchers have linked CINAC to long-term exposure to herbicides (including glyphosate), contaminated drinking water, and heavy metals.

Respiratory damage

Respiratory health is also affected through air pollution. Nitrogen dioxide emissions from fertilizer production and application, together with ammonia emitted from fertilized soils, contribute to $PM_{2.5}$ air pollution that increases the risks of asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease, and lung cancer.[132] A 2022 Nature Food analysis estimated that food system air pollution accounts for 22.4 percent of global mortality attributable to poor air quality,[133] underscoring the substantial public health burden associated with agricultural nitrogen emissions.

Neurological degeneration

Long-term pesticide exposure has been linked to increased risks of Parkinson's disease, Alzheimer's disease, and amyotrophic lateral sclerosis (ALS). A 2019 meta-analysis concluded that occupational pesticide exposure increased the risk of these neurodegenerative diseases by at least 50 percent.[134]

A 2026 systematic review and meta-analysis of 124 studies found that any pesticide exposure was associated with approximately 80 percent higher odds of Parkinson's disease.[135] Pesticides that work by blocking the enzyme responsible for stopping nerve signals increase the risk of Parkinson's disease by up to 455 percent.[136]



Psychological Distress

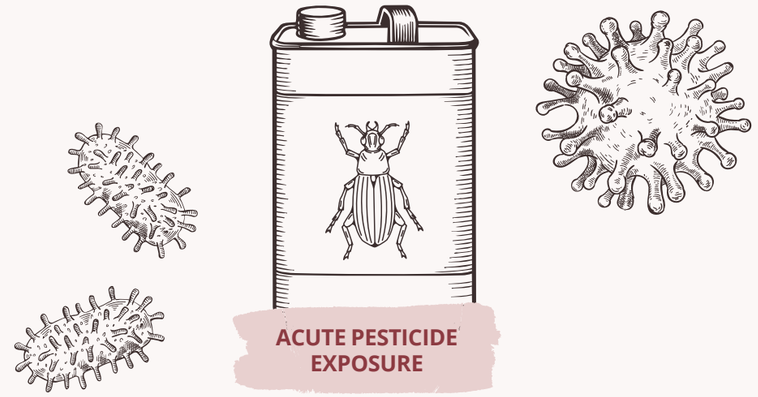
The health impacts of agrochemical exposure also extend to mental health. Repeated exposure to certain pesticides has been linked to depression, anxiety, impaired mood regulation, and suicidal ideation through disruption of neurotransmitter function.[137] Financial pressures associated with chemical-intensive agriculture—including indebtedness, crop failures, and dependence on increasingly expensive agricultural inputs—further compound these biological effects.

The widespread availability of HHPs has created a major but preventable public health crisis. WHO estimates that pesticide self-poisoning accounts for approximately 15 to 20 percent of suicides globally,[138] while evidence from multiple countries shows that restricting access to HHPs consistently reduces suicide mortality.[139] The health burden of agrochemicals extends beyond routine exposure.

Failures in the manufacture, transport, storage, and handling of agrochemicals have caused some of the most severe acute public health disasters associated with modern agriculture, from the 1984 Bhopal gas disaster, which exposed more than half a million people to toxic gases used in pesticides production,[140] to repeated poisonings of children.[141] These events demonstrate that agrochemical risks extend throughout the chemical lifecycle—not only during agricultural use.

Accidental Poisoning

Acute pesticide poisoning remains a major public health concern, particularly among agricultural workers and communities with limited protective equipment, training, regulation, or access to healthcare. Acute exposure can cause skin and eye injuries, respiratory distress, nausea, dizziness, seizures, coma, and death,[142] while repeated occupational exposure has been linked to neurological, endocrine, reproductive, respiratory, immune, and cardiovascular disorders.[143]



Skin and eye injuries, respiratory distress, nausea, dizziness, seizures, coma, and death



15 to 20
of global suicides involve pesticide self-poisoning

Restricting highly hazardous pesticides consistently reduces suicide mortality

Rather than triggering upstream prevention, governments and healthcare systems largely manage—and pay for—these harms, when they are treated at all, normalizing them as hidden costs of food production borne by taxpayers rather than polluters. Many cases remain untreated because cumulative, long-latency exposures are difficult to diagnose or because access to healthcare is limited. Reflecting this broader pattern of cost externalization, a 2017 analysis by the Bureau d'analyse sociétale d'intérêt collectif estimated that the public costs associated with pesticide use in the European Union were more than twice the sector's profits.[144]

Agrochemical dependence creates lifelong cumulative exposure throughout the food system, with people routinely exposed to mixtures of pesticides, fertilizers, and their degradation products through multiple pathways over the course of their lives.

Like its environmental impacts, these health burdens are not isolated externalities but systemic consequences of a food system that substitutes continuous chemical exposure for healthier biological and ecological processes. Protecting human health therefore requires preventing harmful exposures at their source, reducing dependence on hazardous agrochemicals, and accelerating the transition toward agricultural systems that restore healthy environments while placing human well-being alongside productivity as a central measure of success.

Social and Economic Impacts: How agrochemical systems undermine livelihoods, knowledge, and power

Beyond environmental and health impacts, agrochemical dependence has far-reaching social and economic consequences. Rising input costs, price volatility, and extreme weather events (like drought and flooding) push farmers into cycles of debt that limit their ability to exit chemical-dependent systems. At the same time, reliance on costly proprietary inputs and industry extension advisory services erodes farmer autonomy and displaces locally adapted knowledge.

These consequences are a result of the global food system value chains that prioritize cheap commodity production while externalizing social and economic costs. As a result, impacts are unevenly distributed within and between countries: Farmers, households, and communities—often with limited power to influence the systems that shape their livelihoods—face greater risks from agrochemical impacts.

Input shocks and food insecurity

Fossil fuel dependence makes food systems vulnerable to energy and input-market shocks. Price increases in oil and gas raise the cost of synthetic fertilizers and agricultural production, transmitting shocks through food systems to households. In 2022, more than 60 percent of countries and territories covered by the Global Report on Food Crises (GRFC) were reliant on imported fertilizers to meet domestic production demands, leaving them highly exposed to global price and supply shocks.[145]

Financial speculation in agricultural commodities has further amplified food-price volatility beyond changes in physical supply and demand, increasing households' exposure to sudden price shocks.

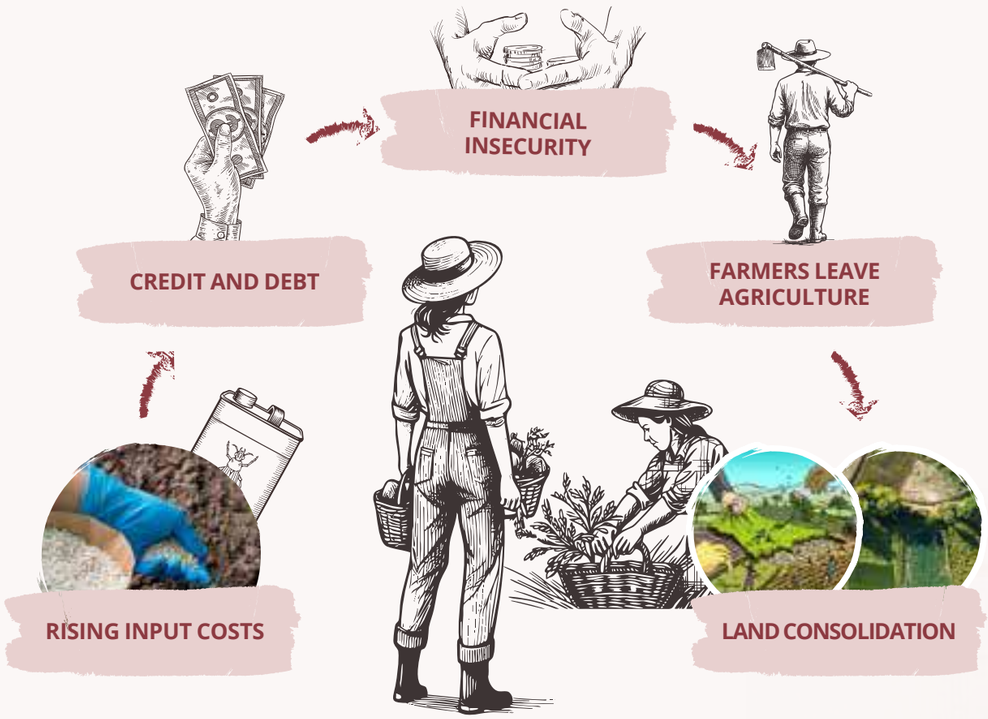
By the end of 2022, global food-price inflation had surged to 10.6 percent, reflecting higher energy and commodity costs alongside widespread supply disruptions related to the Russian invasion of Ukraine.[146] Accounting for the impacts of the conflict, the FAO projects that 23 million additional people will be chronically undernourished in 2030 than previously estimated.[147] The 2026 GRFC warns that additional disruptions to global energy and fertilizer markets—including the closure of the Strait of Hormuz—could raise production costs, put pressure on food affordability, and increase food insecurity.[148]



FAO projects **23 million** additional people chronically undernourished in 2030 after accounting for the impacts of the Russian invasion of Ukraine

Global food-price inflation reached **10.6%** in 2022

>60% of countries and territories relied on imported fertilizers to meet domestic production demands



+29%
increase in credit to agriculture globally, 2014–2023

The largest 1% of farms operate **>70%** of global farmland

Economic pressures and producer livelihoods

Farmers increasingly bear the economic risks of agrochemical-dependent food systems, purchasing fertilizers, pesticides, and seed at high prices while selling into volatile commodity markets.[149] The FAO reports that credit to agriculture increased by 29 percent globally, in real terms, between 2015 and 2024, from USD 961 billion to USD 1.239 trillion.[150] Rising input costs can push farmers into debt or out of farming altogether, contributing to land consolidation.[151]

Agrochemical-dependent farming systems reduce farmers' agency. Commercial production contracts—where a grower and a buyer pre-agree on terms to produce and deliver specific crops or livestock—often dictate the use of specified seed and input packages,[152] while digital agriculture programs increasingly prescribe agrochemical-oriented production methods through proprietary technologies and advisory systems.[153]

Rising debt and decreasing agency has played a significant role in the increasing concentration of agricultural land. The largest 1 percent of farms operate more than 70 percent of the world's farmland,[154] while average land prices have doubled globally over the past 15 years.[155] Millions of farmers are losing access to land as investors and large agribusinesses acquire vast tracts for input-intensive commodity production.[156] A global analysis projects that the number of farms will more than halve by 2100, from 616 million farms in 2020 to 272 million by 2100, alongside an increase in average farm size.[157]





Photo credit: Meg Haywood Sullivan, Climate Visuals Countdown, United States



Resilience and diversity

Agrochemical-dependent food systems can erode communities' control over seed, land, and knowledge, weakening food sovereignty and their capacity to adapt to changing conditions.

The introduction of patented genetically modified seed, accompanied by legal systems restricting farmers from saving and freely exchanging seed, has weakened, and even banned, farmers' ability to select plants suited to local needs and ecologies.[158] Commercial seed systems can displace farmer-managed seed networks, reducing opportunities to save and exchange locally adapted varieties. Evidence from Kenya, for example, describes policies promoting hybrid seed and synthetic inputs as weakening Indigenous seed systems and increasing dependence on commercial suppliers.[159]

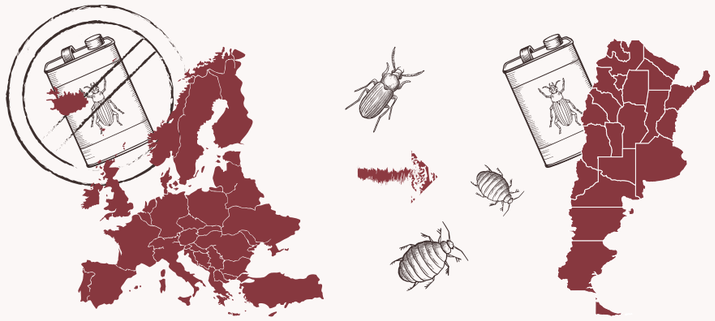
Agricultural diversity has narrowed dramatically. More than 6,000 plant species have historically been cultivated for food, yet fewer than 200 make substantial contributions to global food production, and just nine crops—including the heaviest users of agrochemicals: corn, rice, wheat, and soybeans—account for 66 percent of total crop production.[160]

This concentration reduces the diversity of crops and varieties available for farmers to draw on and adapt to local conditions.

This erosion of locally adapted varieties and agricultural diversity affects knowledge as well as seed. Reliance on standardized technological packages can displace farmers' knowledge of ecological pest management, seed selection, and locally adapted farming practices—a process described as the "deskilling" of agriculture—resulting in increased reliance on agrochemicals.[161] Colonial practices and policies have had a similar impact, eroding food practices, cultural traditions, and intergenerational knowledge associated with harvesting, preparation, and consumption.[162]

Loss of locally adapted varieties can therefore represent more than declining genetic diversity: It can also mean the loss of knowledge and cultural heritage built around those crops. Research in the northern Andes of Ecuador, for example, links agrobiodiversity and seed saving with farmers' knowledge, and cultural relationships with locally maintained varieties.[163]

Photo credit: María Fernanda Fitzgerald, Timbiquí, Colombia



122,000 tonnes
of pesticides prohibited in the EU were approved for export in 2024

106
pesticides permitted in Argentina are prohibited in the European Union

Inequitable standards of protection

Agrochemical regulations vary globally; agrochemicals that are prohibited because of their risks in one country can continue to be produced and exported for use in another. These regulatory differences result in inequitable protections for workers, communities, and environments from highly hazardous pesticides. In 2024, EU member states approved intended exports of almost 122,000 tonnes of pesticides prohibited for use on EU farms because of risks to human health and the environment.[164] Around 14 percent of pesticide exports from the EU to Mercosur countries consist of substances banned or never authorized in the EU itself.[165] Argentina continues to permit the use of 106 pesticides prohibited within the European Union, illustrating markedly different standards of protection.[166] As a result, exposure to agricultural chemicals deemed unacceptable in one jurisdiction continues in others. This compromises human rights and causes disproportionate social and economic impacts for the individuals and communities that do not have adequate regulations.

Agrochemical dependence reshapes people's lives throughout food systems. Farmers face rising costs, financial insecurity, and mounting challenges to their ability to remain on the land; households become more exposed to food-price shocks; communities lose control over seed, knowledge, and locally adapted food systems; and differences in regulatory protections compromise human rights and environments. Together, these impacts weaken food sovereignty and reduce the ability of farmers and communities to shape how food is produced, shared, and sustained. As financial pressures increase and control over land, inputs, and knowledge narrows, the capacity to shift away from agrochemical-dependent production also diminishes.

Reinforcing feedback loops

The risks and impacts surfaced are not merely outcomes from agrochemical-dependent systems; they actively reproduce and reinforce this system. Environmental degradation drives greater input use, health harms are normalized and managed downstream, and social and economic pressures reduce the capacity of farmers and communities to exit chemical-intensive pathways. Together, these feedback loops reinforce agrochemical dependence, narrowing the space for alternative models even in the face of the mounting evidence of harm.

Harms generated by agrochemical-dependent food systems are often treated as unintended side effects. In practice, they are predictable outcomes of production models shaped by fossil fuel dependence, corporate concentration, technological lock-in, and policy incentives—and they feed back into those systems in ways that reinforce dependence over time.

Markets help perpetuate this system by rewarding scale, uniformity, export orientation, and short-term yield gains over diversity, resilience, nutrition, and ecological health. Commodity pricing, input credit, procurement standards, and global supply contracts often make agrochemical-intensive monocultures appear economical, even when they create long-term health, environmental, and livelihood costs. Understanding these impacts as structural is essential for identifying where and how viable alternatives are possible.



Photo credit: Panos Pictures

03

Laying Out the Lock-Ins



The harms generated by agrochemicals do not simply accumulate, they are actively reproduced by interconnected factors that drive the use of agrochemicals and lock in a model of industrial agriculture that relies on and perpetuates their use.

> *The dominance of chemical-intensive agriculture is not accidental but the result of deliberate policy choices shaped by corporate influence, financial incentives, and institutional biases that have evolved over decades.*
>
> **—Alliance for Food Sovereignty in Africa**

Why agrochemical dependence persists

Economic pressures and market control due to corporate concentration prevent farmers and communities from moving away from agrochemicals. Input dependence drives ecological degradation, resulting in greater reliance on external inputs. Policies, finance, and subsidy structures prioritize agrochemical-dependent food systems even as harm grows. Industrial food systems are framed as the only viable solution to food security and climate crises despite evidence to the contrary.

These dynamics do more than constrain change; they actively undermine possibilities for transition: power and resources remain concentrated, while risks and costs are shifted onto farmers, communities, and ecosystems.

This persistence is not a failure of knowledge or lack of alternatives. It reflects deeply embedded structural conditions—or lock-ins—that align markets, technologies, policies, and finance in ways that make agrochemicals appear necessary and alternatives appear unviable. Understanding these lock-ins is essential for identifying where and how meaningful change is possible.



Photo credit: Juliana Adriano for Movimento dos Trabalhadores Rurais sem Terra

Corporate Concentration Lock-In

Controlling Markets and Prices

Research by contributors ETC Group and GRAIN shows that the top four pesticide firms—Bayer, Corteva, Syngenta, and BASF—collectively controlled 56 percent of the global pesticide market and 50 percent of the global seed market in 2024.[167] Fertilizer markets are also highly concentrated, with the top four—Nutrien, Mosaic, Yara, and CF Industries—controlling one-quarter of the market globally, and dominating some national markets at much higher levels.[168] Economists agree that when four or fewer companies control more than 40 percent of a market, the level of concentration is such that competitive balance begins to break down.[169]

Such concentration enables firms to reduce competition and engage in monopolistic pricing, particularly in markets with weak competition law. In Africa, studies by contributor Shamba Centre for Food & Climate and the University of Johannesburg's Centre for Competition, Regulation and Economic Development show that fertilizer prices have reached three to four times world market levels, with African governments effectively becoming captive markets—purchasing fertilizer from a small handful of companies to distribute through subsidy programs.[170]



Market concentration and vertical integration give corporations the power to manipulate prices, control research agendas, limit farmer choice, and capture policy—reinforcing their dominance in ways that make alternatives increasingly difficult to pursue.

PROFITEERING FROM CRISIS AND CORPORATE CONCENTRATION

High levels of corporate concentration allow large firms to profit in times of instability. The U.S.–Israeli bombing of Iran, which began on February 28, 2026, led to the closure of the Strait of Hormuz and a surge in fertilizer prices. Share prices of the world's largest fertilizer companies also soared. Nutrien's share price increased by more than 50 percent, while CF Industries' rose by more than 40 percent.[171] Analysis by DeSmog found that, during the first two months of the war, insiders at CF Industries sold nearly USD 50 million in shares.

During 2020–2022, as the world faced a global food crisis driven by the COVID-19 pandemic and the Russian invasion of Ukraine, the largest fertilizer companies tripled their profits within two years and saw their profit margins climb to 36 percent.[172] Research from GRAIN and IATP showed that price increases far exceeded additional operating costs.

Shaping Science

Agrochemical corporations wield their tremendous resources and power to influence both scientific and regulatory processes—the very processes that are supposed to protect the environment and communities from the impacts of the chemicals they produce.

Research centres and universities around the world often receive funding from agrochemical corporations, a financial relationship that can influence the issues and questions that get scientific attention, as well as the findings that emerge.[173]

Pesticide approval processes frequently rely on industry-funded studies that emphasize short-term toxicity while providing limited insight into cumulative or long-term effects. Corporations have also routinely paid for scientific reviews that were later determined to be systematically biased.[174]

In cases where research findings reveal environmental or health hazards that may lead to regulatory action and harm profits, industry actors have engaged in efforts to discredit and silence scientists through PR campaigns, legal battles, and funding counter-studies.



SUPPRESSING INDEPENDENT SCIENTIFIC RESEARCH

Syngenta's attempt to influence the research of Dr. Tyrone Hayes, a professor of integrative biology at University of California, Berkeley, is one such example. Dr. Hayes was hired by the agrochemical firm Syngenta in the late 1990s to study the effects of its widely used herbicide atrazine. When he found that atrazine had serious negative impacts on the endocrine systems of frogs, the company attempted to block him from publishing his findings. In the years that followed, Syngenta attempted to silence him, lobbied the U.S. Environmental Protection Agency to disregard his research when deciding whether to re-approve atrazine for use, and ran a multimillion-dollar campaign to discredit him and his research.[175]

PROTECTING SCIENTISTS FROM INDUSTRY PRESSURE

In January 2026, Dr. Daniele Mandrioli was abruptly dismissed from his position as director of the Cesare Maltoni Cancer Research Center of the Ramazzini Institute in Italy. Dr. Mandrioli had been leading the Global Glyphosate Study, which found that glyphosate causes "dose-related increases in cancer at multiple anatomic sites in experimental animals, most notably increases in leukemia."[176] The dismissal has been suspected, though not officially confirmed, to be linked to industry pressure over these findings. Dr. Philip Landrigan, head of Ramazzini's International Scientific Advisory Committee, wrote in a January 21, 2026, letter to Institute President Loretta Masotti that the decision appeared to be due to industry pressure and noted the committee had not been consulted on the termination. The Collegium Ramazzini and the Italian Epidemiology Association's journal *Epidemiologia & Prevenzione* both published statements expressing serious concern over the dismissal's lack of transparency, and an Italian public-sector union reported that Ramazzini researchers feared the pesticide industry's response to the study had triggered the firing.[177]

TARGETING CRITICS THROUGH INDUSTRY ASTROTURFING

A 2024 undercover investigation by Lighthouse Reports revealed that a PR firm, v-Fluence, built profiles on hundreds of scientists, journalists, and campaigners critical of pesticides—sharing personal details including home addresses—while coordinating with government officials and executives from major pesticide companies.[178] The impact of this network was made visible in Kenya in 2019. After members of v-Fluence's private social network flagged an upcoming Nairobi conference on pesticide alternatives to the network, a Kenyan policymaker emailed a group that included Bayer and USDA officials to "strategize" against it. Within days, two of the conference's funders—including the African Development Bank—withdrew their support, with the bank citing concerns the event was "one-sided." An AfDB spokesperson later confirmed the withdrawal followed direct contact from Syngenta. As reported by *The New Lede,* the conference's director said he had sensed "unseen forces" working against the event before learning the details.[179]

These disparities are consistent with a broader pattern of institutional path dependence and research priorities that favour conventional, input-intensive agriculture, reinforced by the interests of incumbent actors—including commodity organizations, agrochemical and seed companies, and established research institutions.



Influencing policy and regulation

Corporations spend heavily on lobbying, both individually and through industry associations, to influence and advance policies and regulations that support their interests. This influence also plays out as individuals move between government and private-sector positions, as well as through partnerships between governments and multilateral institutions.

STRENGTHENING TRANSPARENCY AROUND CORPORATE LOBBYING

Bayer—the largest seed company in the world and the second-largest pesticide company—reported global lobbying expenditures of USD 68 million in 2023, along with an additional USD 34 million in trade association fees.[180] These efforts to influence regulation have proven successful both domestically and internationally.

In 2019, Bayer successfully lobbied U.S. government officials to pressure Thailand into reversing a planned ban on paraquat, glyphosate, and chlorpyrifos.[181] In 2021, the company again benefited from U.S. diplomatic pressure, which contributed to delays in Mexico's efforts to restrict the lyphosate.[182] Meanwhile, during the U.S. Environmental Protection Agency's review of glyphosate's registration in 2019, Bayer spent more than USD 9 million lobbying to keep its product on the market.[183]

These close ties between industry and governments can play out in global fora as well. In 2020, the FAO announced its intention to establish a strategic alliance with CropLife International, the trade association representing the world's largest pesticide companies. In response, a global coalition led by PAN brought together 430 civil society and Indigenous People's organizations, nearly 50 philanthropic groups, and close to 200,000 individuals from more than 100 countries, who collectively called on the FAO to end the formal partnership.[184] The coalition argued that elevating a partnership with an industry trade association representing companies invested in the sale of hazardous chemicals undermined FAO's credibility and its ability to fulfill its responsibilities to the world's most vulnerable farmers and fishers.[185] The FAO ended its partnership with CropLife in 2023.

However, as of this writing, CropLife continues to hold official relations with WHO, granted by its executive board, which enables the trade group to attend proceedings of the World Health Assembly.[186]

In 2026, the FAO and the International Fertilizer Association, the trade group representing firms across the sector's value chain, celebrated the continuation of their decade-long partnership, which the FAO notes reflects a shared commitment to "improving fertilizer data and transparency, advancing sustainable nutrient management, and supporting countries in building more productive, resilient and sustainable agri-food systems."[187] Those concerned about the relationship between the industry trade group and the FAO note that it embeds industry interests into global policy processes, poses a conflict of interest, and could lead to the suppression of independent science.

CURBING CORPORATE INFLUENCE THROUGH FRONT GROUPS

In 2024, Bayer launched the Modern Agriculture Alliance (MAA), a U.S.-registered nonprofit that describes itself as advocating for farmers' access to crop-protection tools.[188] Critics describe it as an industry front group set up to push state legislation granting pesticide companies immunity from lawsuits over health harms.[189] According to MAA's 2024 tax filings, it spent roughly USD 13 million in 2024, almost all of it paid to the PR and lobbying firm Penta Group, which also works for Bayer providing advertising and consulting services.[190]

Beginning in 2024, MAA-backed immunity shield bills were introduced in several states, expanding to around a dozen by 2025. A coalition of civil society groups, including compendium contributor from Pesticide Action Network, mobilized opposition, and the bills were defeated in all but three states: Georgia, North Dakota, and Kentucky.[191]

In February 2026, U.S. President Donald Trump issued an executive order directing federal agencies to support glyphosate-based herbicides and pursue legal protections for manufacturers.[192] In June 2026, the U.S. Supreme Court ruled in Bayer's favour in a decision expected to block or limit thousands of current and future lawsuits by restricting state-law failure-to-warn claims related to pesticide labels.[193]



Photo credit: Krishnasis Ghosh Bioversity International

Beyond direct lobbying, industry executives influence regulation by moving from regulatory roles into lobbying firms and back again—what's known colloquially as the "revolving door." Industry representatives also sit directly on regulatory advisory committees, shaping the assessments that determine which substances are approved and at what thresholds.

STRENGTHENING REGULATORY INDEPENDENCE

In the United States, former employees of the Environmental Protection Agency (EPA) are hired by industry as a strategy to more easily navigate the regulatory processes. A 2021 investigation by *The Intercept* found seven of the nine pesticide office directors who left the agency since 1974 went on to work alongside pesticide companies as attorneys, consultants, researchers, and board members.[194] Industry officials are also directly embedded in regulatory processes: For example, Dow Chemical representative served on the EPA's Endocrine Disruptor Screening and Testing Advisory Committee, and former Monsanto lawyers have served as FDA Commissioners, Agricultural Trade Commissioners, and USDA food safety administrators.[195]

Financing Consolidation

Financial systems don't just fund industrial agriculture, they actively shape which farming systems can exist. Banks decide which mergers take place, lenders decide which practices get credit, and investors decide which model of farming counts as a safe bet. Together, these dynamics create a financial architecture that locks in high-input, corporate-controlled agriculture at every level, from the boardroom to the individual farmer's loan application. Major banks demonstrated the role of financial institutions in enabling corporate consolidation in 2016, when they underwrote Bayer's USD 63 billion acquisition of Monsanto.[196]

These financial systems can also constrain agricultural production methods. In the UK, for example, contributor Foodrise found that financing from large banks plays a major role in supporting the expansion and concentration of large companies in the industrialized meat and dairy sector.[197] This "tied credit" model, where credit is extended by an input supplier, processor, or contracting firm on the condition that farmers purchase and use a specific set of inputs, is described as "interlocking contracts" by agricultural economists.[198]

BREAKING THE LINK BETWEEN FARM CREDIT AND INPUT DEPENDENCE

In West and Central Africa's cotton sector, for example, state-run or licensed private monopolies have long provided cotton seed, fertilizer, and pesticides on credit to smallholders, with the loan recovered directly from the farmer's harvest at buyback.[199] A similar pattern appears in India, where several state governments have actively brokered tripartite contract-farming arrangements between banks, agribusiness firms, and farmers, using the contract itself as loan collateral. The Punjab Agro-Industries Corporation (est. 1996) and Tamil Nadu's 2004–05 tripartite cotton model are commonly cited examples, in which the bank's financing is bundled with the agribusiness partner's prescribed seed, fertilizer, and pesticide package.[200]

For investors, farmland has become an increasingly attractive asset class. Agricultural investment funds expanded rapidly between 2005 and 2018,[201] with a pronounced escalation following the 2007–08 global financial crisis, as investors redirected capital from housing and equity markets into commodity index funds. The rapid growth in land and commodity index investment drew billions from institutional investors, including insurance companies, pension funds, foundations, and university endowments.[202] In particular, farmland investment at this time was sought as "safe" in comparison to traditional financial markets,[203] with investors favouring production models capable of delivering high yields—often through intensive input use.

Crop insurance schemes—often publicly subsidized or linked to agricultural credit—can also influence production choices in ways that reinforce agrochemical use.

A study of Kansas farms found that participation in federally subsidized crop insurance was associated with higher spending on fertilizer, agrochemicals, and seed, with insured farms spending an additional USD 2.18 per acre on fertilizer and USD 2.22 per acre on agrochemicals.[204] European research has similarly linked crop insurance uptake to higher pesticide use.[205] Evidence from China has found that insurance schemes can encourage farmers to expand the area under cultivation, potentially increasing total fertilizer and pesticide use, while premium subsidies have been associated with greater fertilizer and pesticide use. How insurance is designed can therefore influence whether it reinforces input-intensive production or supports transitions toward more resilient farming systems.[206]



Photo credit: Murray Cooper–Yuca plant

How did we get here?

In her book *Titans of Industrial Agriculture*, contributor Jennifer Clapp, PhD, explains that the high levels of concentration we see in the agrochemical sectors today did not emerge accidentally—or recently. Agrochemicals have a long political and economic history, dating back to the mid-1800s, when the early international trade in fertilizers and pesticides began to link agricultural production to global commodity markets, industrial capital, and external sources of fertility. Over time, these early market relationships laid the foundation for the corporate consolidation and systemic lock-in evident today.[207]

Pre-1800s to mid-1800s
Ecological foundations of farming

For most of agricultural history, soil fertility and pest management were maintained through ecological processes such as manure application, crop rotations, and crop and livestock biodiversity. From the mid-1800s, internationally traded fertilizers—including guano, bones, nitrates, and potash—began to supplement and gradually displace local nutrient cycling. While these inputs increased yields, they also marked an early shift toward dependence on externally sourced fertility.[208]

Mid-1800s to early 1900s
Mechanization and fertility tied to fossil fuels

The expansion of mechanization, the production of which was initially powered by coal and later by oil, supported larger fields and more uniform cropping patterns.[209] The development of synthetic nitrogen fertilizer using the Haber–Bosch process fundamentally reoriented soil fertility from biology to chemistry. This orientation to fossil fuel–intensive industrial production embedded long-term dependence on energy-based inputs.[210]

1920s to 1940s
Seeds, chemicals, and early input dependence

Hybrid seeds and early synthetic pesticides were developed to perform reliably under uniform, high-input conditions.[211] The expansion of agricultural production into larger, mechanized fields promoted increasingly uniform monoculture cropping systems. Continuous cultivation of the same crop depleted soil nutrients and intensified pest pressures, shifting crop management toward synthetic fertilizers and pesticides and reinforcing dependence on agrochemical inputs.[212]

1950s to 1970s
Globalizing input-intensive agriculture

A set of agricultural interventions, which included hybrid seeds that need to be purchased every year and whose yields depend on pesticides, synthetic fertilizer, and irrigation, was developed in the 1950s. This approach was later dubbed the "Green Revolution," from a 1968 speech by William Gaud, then head of USAID, who positioned these interventions in relation to the powerful geopolitics of the time: "Developments in the field of agriculture contain the makings of a new revolution," he said. "It is not a violent Red Revolution like that of the Soviets, nor is it a White Revolution like that of the Shah of Iran. I call it the Green Revolution."[213] The practices enabled monoculture production at scale and were promoted by research institutions, development programs, and extension services and funded heavily by private philanthropy. While production temporarily increased in some regions, these interventions entrenched monocropping, reduced crop diversity, and normalized the use of fertilizers and pesticides as standard components of agricultural practice.[214]

1980s to early 1990s
Intellectual property and seed system restructuring

Changes in patent law allowed intellectual property protections to be applied to genetically engineered organisms in 1980, with the landmark Diamond v. Chakrabarty U.S. Supreme Court case.[215] Restrictions on seed saving expanded alongside these changes, shifting control over seed systems from farmers to commercial firms and accelerating consolidation across seed and agrochemical markets.[216]

Mid-1990s to 2000s
Biotechnology and chemical intensification

The commercial introduction of herbicide-tolerant genetically modified (GM) crops integrated seeds and chemical inputs into proprietary production systems.[217] Roundup Ready seed was introduced by Monsanto in 1996. Designed to be resistant to Monsanto's glyphosate-based Roundup herbicide, Roundup Ready seeds quickly dominated corn and soy production. This drove sharp increases in herbicide use and contributed to the rapid emergence of resistant weeds, deepening technological and ecological lock-ins.[218] Significantly, the introduction of patented GM seeds, accompanied by legal systems prohibiting farmers from saving and freely exchanging seed, marked a disastrous rupture between farmers and their ability to select plants suited to local needs and ecologies.[219]

2000s to present
Consolidation and system stabilization

Mergers across seed, pesticide, and fertilizer industries concentrated market power within a small number of transnational corporations.[220] Input provision, advisory services, and technological development increasingly converged, reinforcing production systems structured around purchased inputs and narrowing the space for alternative pathways.[221]

2010s to present
Digital agriculture and the extension of system control

Digital technologies—including precision agriculture tools, data platforms, and artificial intelligence—have been layered onto existing agrochemical-intensive systems.[222] Framed as efficiency-enhancing, these tools shift decision-making toward proprietary software and algorithmic advisory systems, reinforcing dependence on digital platforms while stabilizing agrochemical-dependent production models.[223]

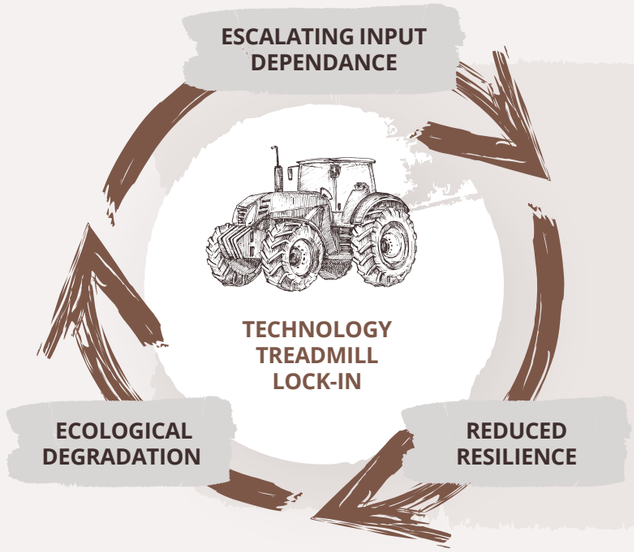
Technology Treadmill Lock-In

Industrial farming systems are organized around a tightly coupled set of technologies—synthetic fertilizers, pesticides, mechanization, irrigation, and input-responsive proprietary seeds—that are designed to drive and lock in agrochemical use. Once adopted, these technologies actively shape production in ways that make transitions away from agrochemical-dependent pathways difficult.

Input dependency

Synthetic fertilizers substitute for ecological nutrient cycling, enabling continuous monocropping while degrading soil structure, organic matter, and biodiversity.[224] As soils lose resilience, maintaining yields increasingly depends on external inputs—reinforcing reliance on the very products that caused the degradation. Chemical pest and weed control simplifies agroecosystems, creating conditions in which resistance becomes more likely and intensified interventions are required.[225] This ratcheting up of chemical treatments further degrades ecosystem integrity, placing farms on a costly technological treadmill from which exit becomes progressively harder.[226]

Agrochemical companies promised farmers that GM seeds would boost yields while decreasing pesticide use[227] and simplifying weed management. Yet the opposite occurred. Glyphosate use, for example, increased fifteenfold between 1996 and 2014, as the cultivation of GM glyphosate-resistant seeds increased.[228] By 2015, it was the most widely used herbicide in the world. By 2020, global annual glyphosate use was estimated at 749.27 million kg of active ingredient, accounting for 44 percent of the total volume of herbicide active ingredients used worldwide.[229] The introduction of patented seeds "marked an abrupt fissure in human history," explains contributor PAN. When farmers lost ownership of seeds, they also lost the ability to select plants best suited to local ecologies and social preferences. In their 2025 report, PAN stated, "It was up to Monsanto to decide what varieties farmers would grow, in return for getting seed resistant to their proprietary pesticide."[230] If farmers wanted their crops to be resistant to a pesticide, they had to purchase seeds with whatever traits Monsanto offered, regardless of taste, yield, or resilience to local conditions.



Proprietary input packages and financial incentives bind farmers to specific production methods that generate ecological and agronomic conditions—soil degradation, pest resistance—that escalate dependence on external inputs, demanding ever more of the technologies that created them.

ADDRESSING THE CYCLE OF HERBICIDE RESISTANCE

Since 1996, 62 weed species across the world have developed resistance to glyphosate.[231] In response, companies now encourage farmers to apply formulations containing older, more toxic active ingredients, such as dicamba, which can vaporize and drift for miles, affecting non-target plants, and 2,4-D, which has been linked to cancers and endocrine disruption.[232] Companies are also "stacking" multiple GM herbicide-tolerant traits together in a single seed so that farmers can spray additional herbicides on their GM crops.[233]

Proprietary Control

Contractual arrangements and patent enforcement further constrain farmer choice. Restrictions on seed saving, prescribed input regimes, and legal exposure associated with proprietary technologies increase financial risk while narrowing the range of viable production pathways.[234] The commercialization of GM crops increasingly linked proprietary seed varieties with dedicated herbicides, reinforcing economic incentives for continued agrochemical use. At the same time, the expansion of contract farming enabled large agribusinesses to prescribe the seeds, fertilizers, and pesticides required for production, reducing farmers' autonomy over management decisions. This integration of corporate supply chains and input-dependent production further entrenched reliance on proprietary agricultural technologies and chemical-intensive farming systems.[235]

Contributors from the Global Collaboration for Resilient Food Systems and AFSA point to advisory systems as a compounding factor: In many parts of the world, extension services and input recommendations have effectively become marketing arms for agribusiness.[236] This dynamic is documented concretely in the 2020 *False Promises* report. [237]

It found that the Alliance for Green Revolution in Africa (currently known as AGRA), which was founded in 2006 and works within the Comprehensive Africa Agricultural Development Program to improve agricultural practices in Africa, initially focused its efforts on promoting corporate seed and fertilizer packages, leaving many unable to repay loans after poor harvests. Peer-reviewed research confirms the underlying mechanism: Input dealers acting as extension agents "have an incentive to suggest relatively costly inputs."[238]



Photo credit: Murray Cooper–A local Indigenous Quichua farmer

STRENGTHENING INDEPENDENT AGRICULTURAL ADVISORY SERVICES

Research conducted in 2022 in the Andes found that almost 90 percent of pesticide application recommendations provided by retailers and chemical company representatives to smallholder farmers using their products were incorrect in some way when compared to product datasheets. One-third of recommendations from retailers were for doses up to eight times higher than the stated upper bound, and nearly half involved recommending the wrong pesticide for a particular pest problem.[239]

REBUILDING PUBLIC AGRICULTURAL EXTENSION SERVICES

Between 2010 and 2020, herbicide use in Brazil grew by 128 percent, from 157,500 to 329,700 tonnes of active ingredient sold annually,[240] even as cultivated area expanded by only 24 percent. This increase was driven largely by declining glyphosate efficacy and the resulting shift to other, often more toxic, chemistries. By 2021, Brazil had become the world's largest pesticide consumer, applying more pesticide by volume (719,500 tonnes) than the United States and China combined (701,000 tonnes for the two countries) and at a rate of 10.9 kg per hectare, roughly twice the per-hectare rate of Argentina or Indonesia.[241] An estimated 30 percent of the pesticides used in Brazil are banned in the European Union.[242]

Brazil illustrates how deeply agrochemical interests can become embedded in a country's agricultural system. Public extension capacity has weakened over decades; Brazil's national extension agency, EMBRATER, was defunded and closed in 1990, leaving a "pluralistic" patchwork of public agencies, private firms, and company-run advisory services to fill the gap.[243]

False Solutions

In response to growing concern about synthetic fertilizers and pesticides, agrochemical firms have expanded investment into biological pesticides and fertilizers. Biologicals (or bioinputs) include a range of products derived from biological processes (as opposed to chemical synthesis), such as pesticides sprayed on crops or stimulants applied to soils to increase plant growth. But there is no standard definition, and regulations of these products are lax.[244] According to industry estimates, the biologicals market is expected to grow to nearly USD 35 billion by 2030.[245]

Although companies actively position bioinputs as "green" alternatives, evidence compiled by contributors GRAIN, ETC Group, PAN, and IPES-Food indicate that guidance from the top pesticide companies clearly state that their biological products are not meant to replace "traditional crop-protection products" but, rather, to be used alongside them.

Moreover, while the companies describe their biologicals as "natural products," this can be misleading because these products can involve GM microorganisms that raise biosafety issues.[246]

Fertilizer companies are also investing in biofertilizers and biostimulants, marketing these as "complementary" additives to their synthetic fertilizers. Contributors raised concerns about the emergence of green fertilizers—which use renewable energy instead of fossil fuels to produce the hydrogen inputs required for the Haber–Bosch process.[247] Although greenhouse gas emissions are reduced upstream, the production process itself is extremely energy- and water-intensive, making scalability constrained by both renewable capacity and water use.[248] It also does not solve the problems associated with excessive use of synthetic fertilizers, such as diminished soil health, biodiversity loss, on-field greenhouse gas emissions, nitrate pollution, and overdependency on external inputs.



CHALLENGING FOSSIL-BASED CLAIMS OF SUSTAINABILITY

In a joint investigation with *The Guardian,* nonprofit investigative outlet DeSmog revealed that Yara's "climate-choice" fertilizers, which the company promotes as part of its nature-positive and climate-smart farming agenda,[249] rely on ammonia produced from fossil gas, with emissions managed through a carbon capture and storage (CCS) approach.[250] Marketed at a green premium, including through Yara's July 2024 agreement with PepsiCo Europe to supply lower-carbon crop-nutrition products,[251] CCS-based fertilizers perpetuate the use of fossil fuels and offshore drilling. Since 2021, when blue hydrogen started ramping up in the United States, extraction has increased by approximately 20 percent, from less than 100 billion cubic feet per day to over 118.5,[252] and planned ammonia facilities are set to quadruple production in the country.[253]

These false solutions function less as pathways out of corporate-controlled chemical dependence and more as means of adapting agrochemical-intensive systems to shifting regulatory, market, and reputational pressures.

Digitalization

The world's largest agricultural input companies are increasingly positioning digital farming platforms as a core part of their business model. Bayer, Corteva, Syngenta, and BASF have all developed digital strategies that link seeds, crop protection, fertilizer advice, machinery data, satellite imagery, weather information, and farm-management analytics into integrated commercial systems.

Industry claims that digital farming platforms will reduce agrochemical use,[254] yet the fact that companies have reshaped their business model around these platforms suggests that this approach is intended to support rather than undercut agrochemical sales.

PROTECTING FARMER AUTONOMY IN DIGITAL AGRICULTURE

The business logic is clear: These platforms turn farm data into product recommendations, guiding decisions on seed rates, fertilizer, herbicides, fungicides, and insecticides through company software, retailers, and advisers. Bayer's Climate FieldView, for example, promotes seed, fertility, and crop-protection prescriptions that can be sent directly to equipment. Farmers receive algorithmically generated input "prescriptions" that favour the companies' own products and promote chemical-intensive practices.[255]

Control over agricultural data is central to this shift. Contributor Jim Thomas from Scan the Horizon explains further: "This shift to digital farming benefits not only the big input companies but also big tech firms (such as Amazon, Microsoft, and Google), who provide cloud and AI infrastructure."[256]

Farmers and advocates for reducing input reliance are concerned that digitalization technologies further entrench reliance on agrochemicals by embedding fertilizer- and pesticide-intensive production within data-driven infrastructures. As software, analytics, and advisory services become increasingly proprietary, decision-making authority shifts away from farmers and toward the firms that own digital infrastructure and intellectual property.[257]

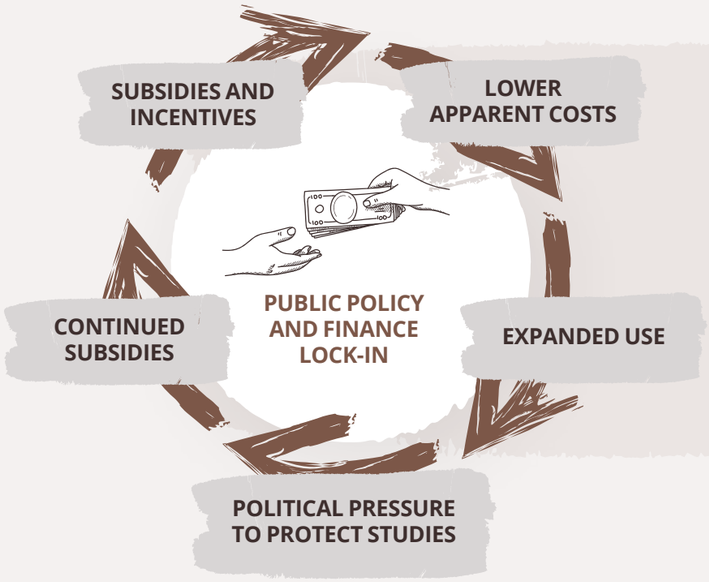
> *Digital platforms allow corporations to effectively dictate agricultural practices and push their products on millions of hectares across the world.*
>
> **—ETC Group & GRAIN**



Public Policy and Finance Lock-In

Public policy and finance play a decisive role in shaping the economic conditions under which agrochemical-dependent food systems operate. Contributor IPES-Food documents how, for decades, many governments around the world have prioritized policies that promote the production of cheap and abundant food calories, with little regard to the long-term impacts and externalized costs.[258] Chemical-intensive industrial agriculture has been actively sustained by governments through subsidies, regulatory choices, and public investment decisions that keep it economically viable while insulating governments from political backlash over rising food prices, despite worsening food security and nutrition.[259]

Over the last two decades, billions of dollars of institutional investor capital have flowed to commodity index instruments and agricultural futures, contributing to a global food economy that is increasingly governed by a financial logic rather than agronomic need. Financial speculation in commodity markets intensifies the price volatility that compresses farm margins and undermines the income stability on which diversified, low-input, and agroecological farming transitions depend.[260] The global agribusiness firms that supply the agrochemical inputs on which commodity monocultures depend profit from this commodity price volatility, contributing to a substantial increase in agrochemical use over this same time period.[261]



Subsidies, trade rules, and financial mechanisms that externalize the harms of chemical-intensive production make industrial food artificially cheap, creating political pressure to protect those same structures—locking governments into a system whose true costs remain invisible.

> *The economic incentives are massively skewed in favour of chemical agriculture, masking its true costs at the expense of local and territorial markets, based on assumptions about the ability of these chains to deliver "cheap" food.*
>
> **—International Panel of Experts on Sustainable Food Systems**

Subsidies and public investment

Government subsidies are among the most powerful mechanisms locking in agrochemical dependence. The FAO reports that nearly 90 percent of the USD 540 billion spent annually on agricultural subsidies globally supports chemical-intensive commodity crop production.[262] Of this, approximately USD 245 billion annually is given to farmers as fiscal subsidies, and 70 percent of that is tied to the production of a specific commodity or use of a specific input.[263]

These subsidies can reward higher production volumes rather than ecological or nutritional outcomes, systematically favouring yield maximization through increased fertilizer and pesticide use. Direct input subsidies provide farmers with agrochemicals at below-market cost, shaping expectations and production practices while transferring public resources to input suppliers.

REDIRECTING INPUT SUBSIDIES TOWARD DIVERSIFIED AGRICULTURE

Between 2011 and 2015, the governments of 10 sub-Saharan African countries—representing more than half the region's population—adopted a new generation of fertilizer input subsidy programs (ISPs), spending between USD 600 million to 1 billion annually on fertilizer subsidies, accounting for between 14 percent and 26 percent of their combined public agricultural expenditure.[264] Designed as "market-smart" subsidies intended to correct the failures of earlier subsidy programs, these ISPs instead embed chemical fertilizer use deep within national agricultural development strategy, often at the expense of investment in research, extension services, or diversified input systems. Country-level data illustrate the scale of the lock-in: In the early 2020s fertilizer subsidy rates reached as high as 85 percent of the input's cost in Malawi, 50 to 70 percent in Mozambique, and 40 to 50 percent in Mali.[265] In Nigeria, subsidy programs cost close to USD 150 million annually between 2008 and 2010.[266] Across the region, input subsidies have at times accounted for 60 to 70 percent of total public agricultural spending. The result is a self-reinforcing cycle: Large upfront public investment creates political constituencies including farmers, input suppliers, and officials with a stake in continuation, regardless of the program's actual productivity or environmental performance.

Fossil fuel subsidies further skew the playing field: In 2024, fossil fuel subsidies reached USD 7 trillion,[267] keeping the cost of synthetic fertilizer production artificially low.

Carbon capture and storage (CCS) subsidies represent a newer channel of public support flowing between fossil fuel and agrochemical industries. Ammonia production is described within industry as the "low-hanging fruit for CCS," since it releases a highly concentrated CO_2 stream that is comparatively cheap to capture.[268] Fertilizer and fossil fuel companies have leveraged this advantage, branding the resulting "blue ammonia" as low carbon to secure subsidies for new infrastructure, including under the U.S. Inflation Reduction Act.[269] New CCS-linked fertilizer facilities being built at time of writing—such as CF Industries' Louisiana ammonia complex—are designed to run for decades, deepening rather than dismantling fossil-agrochemical lock-in.

Beyond explicit subsidies, analysis by contributor Ursa Collective highlights how agrochemical systems benefit from substantial implicit subsidies through externalized costs. In Nepal, the cost of pesticide-related illness for farmers due to pesticide use was nearly one-third of total annual healthcare costs.[270] The FAO calculates environmental costs from agriculture-related nitrogen emissions at over USD 1.45 trillion annually.[271]

Research by Systemiq estimates the global human health costs of toxic chemical exposure attributed to the food system at USD 816 billion annually.[272] These costs are borne by health systems, ecosystems, and communities—not by the firms whose products generate them.

Development finance

Development finance bodies actively incentivize agrochemical-intensive agriculture. In March 2024, the International Finance Corporation—the private-sector arm of the World Bank Group—led a USD 1.25 billion financing package for fertilizer company Indorama Eleme Fertilizer in Nigeria, which was used to expand their urea production capacity by 1.4 million tonnes/year.[273] Independent analysis found that IFC's agribusiness portfolio remains concentrated in large corporate lending, averaging USD 57.6 million per deal, with only a quarter of projects even referencing smallholder benefits.[274] In October 2025, the World Bank Group launched AgriConnect, an initiative pledging to double agribusiness financing to USD 9 billion annually by 2030.[275]



REBUILDING PUBLIC AGRICULTURAL SYSTEMS

Structural adjustment programs imposed by the World Bank and International Monetary Fund in the 1980s and 1990s required the dismantling of state-run agricultural extension services and state input systems, creating vacuums that multinational agribusinesses quickly filled.[276] The World Bank's Enabling the Business of Agriculture program, which ran from 2013 to 2021 and established policy frameworks in 101 countries, privileged large-scale, input-intensive farming, including the privatization of seed systems.[277]

Contributor AFSA explains the long-term effects of these reforms: In Nigeria, land governance reforms facilitated large agribusiness land grabs, suggested to be more than 1 million hectares between 2004 and 2020, that displaced local farmers and agroecological practices.[278] In Zambia, the push for input-intensive farming resulted in 63 percent of smallholder farmers reporting dependence on purchased inputs for basic production, with application rates exceeding that of neighbouring countries.[279]

Philanthropic institutions and development agencies have worked together to support industrial agriculture models: Post-war public and private funding supported the research and dissemination of Green Revolution technologies framed as solutions to hunger, establishing knowledge systems and infrastructure that continue to shape policy priorities decades later.[280] Most notable is the Alliance for a Green Revolution in Africa (AGRA), which was founded in 2006 and initially worked with the global fertilizer industry to subsidize and boost the use of commercial seeds and synthetic fertilizers in more than a dozen countries across the continent in an attempt to increase yields.

SHIFTING INVESTMENT TOWARD AGROECOLOGICAL APPROACHES

A 2022 independent evaluation of AGRA—which had received over USD 1 billion in philanthropic funding since 2006—found that despite initial productivity gains, hunger increased by 30 percent and agrochemical use rose by 51 percent.[281] Many donors and governments now recognize these effects and are exploring support for agroecological approaches. AGRA is actively integrating regenerative approaches into its 2023–2027 strategy, focusing on restoring soil health, diversifying crops, and increasing smallholder resilience to climate shocks.[282] Despite this shift, earlier investments continue to shape infrastructure, knowledge systems, and policy expectations.[283]

Regulation, trade, and geopolitics

Contributors outlined how regulatory frameworks, global trade, and geopolitics complicate agrochemical dependence. The US–Israel war in Iran has triggered an alarming fertilizer crisis, laying bare how concentrated and weaponizable agrochemical-dependent supply chains can be. Middle East disruptions have put roughly one-third of global seaborne fertilizer trade at risk through the Strait of Hormuz, driving urea prices up an estimated 60 percent in 2026.[284] This volatility is happening because fertilizer production and supply are concentrated in a few countries: Over 55 percent of global urea production occurs in four countries—China, India, Russia, and the U.S.—while China, Russia, Saudi Arabia, and Qatar account for 41 percent of nitrogen fertilizer exports.[285] Russia's 2022 export restrictions, which removed 15 percent of global fertilizer supply overnight, already showed how directly this leverage can be deployed.[286] Because nearly half the world's population is currently dependent on food grown in commodity crop systems with synthetic fertilizer, disruption here hits food security more directly than any pesticide trade dynamic. Agrochemical lock-in, once built through decades of subsidy, now doubles as a lever for coercion in conflict.

Another persistent feature of agrochemical geopolitics is the export of pesticides produced in countries where their use is banned to countries without such bans, after which they can circulate back into global markets through food imports.[287] Dubbed the "circle of poison" by investigative journalists David Weir and Mark Schapiro in their landmark 1981 book *Circle of Poison: Pesticides and People in a Hungry World,* this dynamic has been the subject of concern among advocates for decades.[288]

Despite these concerns, in 2018 alone, more than 81,000 tonnes of pesticides containing 41 different hazardous chemicals banned for agricultural use in the EU were exported by European corporations.[289] Around 14 percent of the total volume of pesticides exported by the EU to the Mercosur countries—the South American trade bloc comprising Argentina, Brazil, Uruguay, and Paraguay—consists of substances that are banned or have never been authorized in the EU itself.[290]

Exporting substances deemed too hazardous for domestic use while importing food contaminated with those same chemicals raises clear ethical and public health concerns. Despite these risks, the substantial economic value of the pesticide export market continues to shape policy and trade priorities. In 2024, the market was valued at USD 41.7 billion, with the top five exporting regions accounting for more than 60 percent of global sales.[291]

Pesticide Export Value by Region, 2023

COUNTRY	VALUE (MILLION USD)	SHARE OF TOTAL (%)
China	9,184	**22**
United States of America	4,830	**12**
India	4,142	**10**
France	3,551	**9**
Germany	3,513	**8**
Other	16,514	**39**

Contributor PAN highlights how these double standards persist. For example, in September 2022, Germany announced a ban on exporting pesticide products containing EU-banned ingredients, but exports of the active ingredients themselves continue to remain a loophole.[292] On the import side, similar inconsistencies apply. To accommodate trading partners, the European Commission permits food imports with residues from pesticide banned in the EU as long as they are below established maximum residue limits.[293]



Trade policy further reinforces these dynamics. To protect this revenue stream, the U.S. government and the agrochemical industry have a history of undermining other countries' attempts to ban pesticides and GMOs.

PROTECTING NATIONAL POLICY SPACE FROM TRADE PRESSURE

When Thailand announced plans to ban the pesticides paraquat, glyphosate, and chlorpyrifos, the U.S. Department of Agriculture (USDA) sent a series of letters stressing that Thailand would lose access to imports from the United States, especially wheat and soy, which are grown in the U.S. with glyphosate.[294] These efforts forced Thailand to drop the proposal. Also in 2019, the first Trump administration offered to double its aid package to Colombia if the country reinstated glyphosate use.[295] In this case, Colombia kept its ban.

Externalized costs

In 2024, the FAO estimated that the global hidden costs of agri-food systems exceeded USD 10 trillion annually.[296] More than 70 percent of these costs are associated with unhealthy diets high in ultra-processed foods, fats, and sugars, which contribute to obesity and non-communicable diseases and resulting losses in labour productivity, particularly in high- and upper-middle-income countries. Around one-fifth of the total is linked to environmental impacts, including greenhouse gas and nitrogen emissions, land-use change, and water use. Even these estimates are likely conservative: Environmental costs may be underestimated due to data limitations, while associated healthcare costs were excluded because the assessment classifies them as visible rather than hidden costs.

Enabled by public subsidies, regulatory permissiveness, and private finance, the true costs of environmental damage and health harms stemming from agrochemicals are not borne by the companies producing them. Externalizing these costs results in higher profit margins, while reinforcing the production of cheap commodity-crop-based calories.

Although these costs are ultimately paid for by the public, the price of food is a major social policy focus for many governments.[297]

In many high-income countries, consumers have become accustomed to spending a shrinking share of household income on food—by 2023, food accounted for just 12.9 percent of U.S. household expenditures.[298] In this context, large-scale industrial production has been justified on the basis of meeting these expectations and keeping cheap commodities flowing. Agrochemical firms position themselves as protectors of affordability, arguing that restrictions on pesticides or fertilizer subsidies would raise food prices.[299] Prioritizing short-term consumer prices can constrain policymaking by privileging affordability over the long-term costs imposed on farmworkers, ecosystems, public health systems, and future generations, allowing these impacts to remain externalized.[300]

INTERNALIZING THE HEALTH AND ENVIRONMENTAL COSTS OF FERTILIZERS

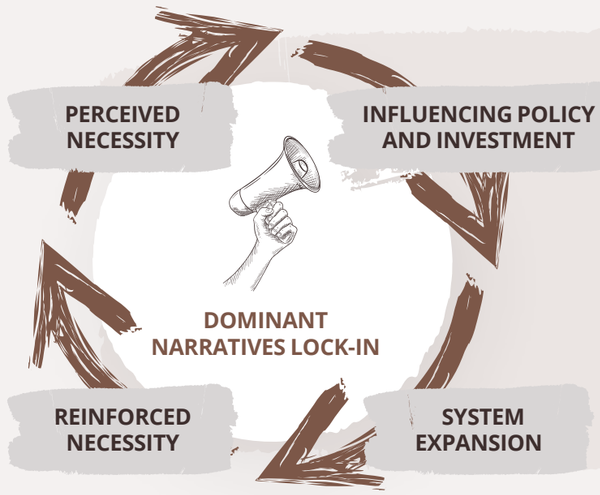
A 2022 study estimated the environmental and human health costs of nitrogen fertilizers in EU member states at almost USD 82 to 374 billion per year. The authors argue that these costs are substantial enough that the social benefits of reducing nitrogen use would exceed private losses.[301]

Ultimately, by shaping expectations around price, convenience, and productivity while obscuring subsidies and externalized costs, these dynamics constrain political space for policies that would prioritize health, equity, and ecological resilience, making alternatives appear not merely difficult but economically unviable.



Dominant Narrative Lock-In

Agrochemical dependence is sustained not only through markets, technology, and policy, but also through dominant narratives that shape how food system problems are defined and which solutions appear legitimate. These narratives circulate through corporate communications, research partnerships, policy discourse, and media coverage—functioning less as passive descriptions of reality than as active forces that foreclose alternatives. They cut across all three structural lock-ins, legitimizing corporate power, technological dependency, and policy choices, making agrochemicals appear necessary, manageable, and inevitable.



These lock-ins are upheld by dominant narratives that position industrial food systems as the only viable solution to food security and the climate crisis, obscuring evidence to the contrary, normalizing the harms they generate, and shaping how food system problems and solutions are understood.

Narrow food security framing

> *The agrochemical industry's most powerful narrative is that agrochemicals are indispensable to global food security.*
>
> **—ClimateWorks Foundation**

The dominant framing of food security places aggregate production volumes at the centre of the debate. Projections of population growth and yield gaps are mobilized to justify continued expansion of input-intensive agriculture, while other dimensions of food security—such as nutrition density, access, affordability, diversity, resilience, livelihoods, conflict, and power—receive far less attention.[302]

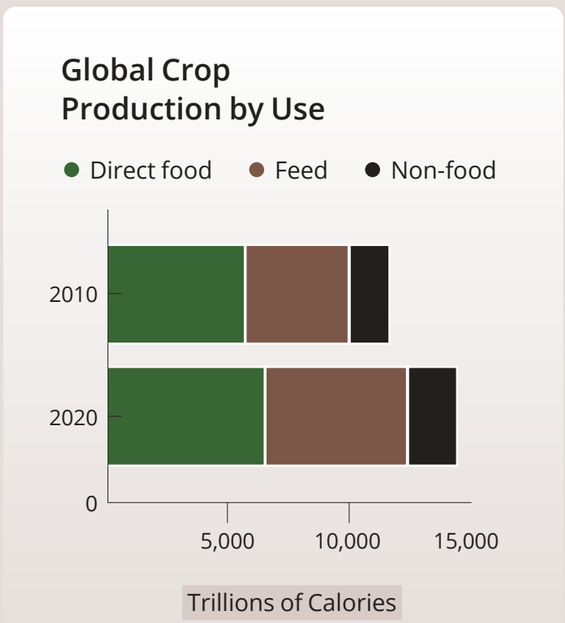
Agrochemical firms and other powerful actors systematically invoke this framing: Pointing to projected population increases by 2050, Bayer has argued, "We will need to see at least a 50 percent increase in food productivity."[303] However, leading academics disagree, arguing that by 2012 the world already produced "enough food to feed 10 billion people, which is the number our population is predicted to reach by 2050."[304]

The United Nations agrees that "today's global food production is enough to feed everyone on the planet," while also acknowledging that "hunger continues to increase in some parts of the world."[305] The UN International Fund for Agricultural Development (IFAD) expands on this, stating, "An uncomfortable truth: Small-scale rural farmers, the people who produce most of the food we eat, are those most likely to be hungry and poor."[306]

Despite the far-reaching environmental, health, and social harms that extend well beyond the fields where these inputs are applied, agrochemical use has been normalized. Industry frames agrochemicals as being necessary to "feed the world," while ignoring the many harms that accompany them. Meanwhile, only a minority of crops produced through industrial systems are used for direct human consumption.[307]

RETHINKING YIELD AS A MEASURE OF FOOD SYSTEM PERFORMANCE

Historical productivity gains demonstrate fundamental issues with the yield productivity logic used to justify agrochemical-intensive expansion. Between 2010 and 2020, total calorie production increased by 23.9 percent, yet available calories per person increased by only 9 percent. Increases in livestock feed use (31.2 percent) and non-food uses (36.2 percent) absorbed most of the gain. In total, less than half of all calories produced on croplands in 2020 were available for human consumption.[308]



Ultimately, the narrative that agrochemicals feed the world obscures how chemical-intensive monocultures directly undermine the food security agrochemical companies claim to serve by degrading soils, ecosystems, and biodiversity essential for resilient agro-ecosystems;[309] diverting large shares of crops toward bioenergy, animal feed, and nutrient-poor ultra-processed foods;[310] and ignoring the root causes of hunger such as inequality, conflict, and market failure. These narratives also help to explain the limited scrutiny applied to the harms associated with agrochemical production and use.

Greenwashed climate solutions

> *The defining feature of truly regenerative agriculture is elimination of agrochemicals that contribute to climate change, destroy soil life, decimate biodiversity, and devastate human health. Indeed, if the burgeoning regenerative agriculture movement is going to fend off greenwashing and meet its ambitious and critical goals, it is essential that agrochemical reduction becomes a central tenet.*
>
> **—Friends of the Earth**

As climate crisis concerns have intensified, agrochemical companies have responded by marketing their products and approaches as being climate solutions, while continuing to produce and market inputs with serious environmental impacts.[311] Corporate co-opting of the term "regenerative agriculture" is a notable example. Contributor Friends of the Earth explains how companies are investing significant resources in promoting the narrative that conventional, no-till agriculture is a "regenerative" climate solution, while these production methods continue to rely on synthetic fertilizers, pesticides, and seeds genetically engineered to withstand herbicides like glyphosate. One-third of pesticide use in the United States can be attributed to corn and soy grown in no-till systems, reinforcing demand for fossil fuel–based inputs rather than providing a pathway away from agrochemical dependence.[312]

Industrial production models are presented as addressing climate risks and enhancing food security, but the evidence suggests otherwise. The 2023 IPCC report noted that during climate shocks, industrial monocultures have repeatedly failed, while agroecological systems—marginalized by these narratives—have demonstrated significantly greater resilience.[313] Indeed, a 2024 systematic evaluation that synthesized over 100 primary research papers across decades of climate and agricultural science confirmed that large-scale monocropping in climatically erratic conditions with unpredictable rainfall patterns have increased risk of catastrophic loss compared to diversified organic and agroecological farming.[314]

Normalized harm

Agrochemical-dependent food systems are reinforced by narratives that frame harm as acceptable, manageable, and already under control. Health and environmental impacts are treated by companies and policymakers as externalities to be addressed downstream through publicly funded systems, rather than as preventable outcomes of food system design. Regulatory frameworks reinforce a perception of safety: authorities emphasize that agrochemicals are safe "under conditions of use," relying on risk assessments that evaluate the short-term effects of individual substances while excluding cumulative, long-term, and synergistic exposures that reflect real-world conditions. Regulations are also inconsistent, with some pesticide substances whose residential uses have been cancelled or substantially restricted remaining permitted for agricultural applications.[315]

These distinctions downplay the risks of exposure and reinforce the assumption that food system use is acceptable.

In many countries, public health funding is largely spent on treating chronic diseases and managing environmental exposure, while comparatively little investment is made in preventing harm.[316] Illnesses linked to toxic agrochemical exposure—including cancers, metabolic disorders, endocrine disruption, and neurological conditions—are addressed primarily through healthcare systems rather than upstream interventions. In this way, the causal link is downplayed, and harm is normalized as a routine cost of food production rather than recognized as a preventable outcome of policy and investment choices.

EXPANDING PROCUREMENT BEYOND SYNTHETIC INPUTS

Contributor Shamba Centre notes that current input procurement policies in many African countries do not consider organic fertilizers or other alternatives. While governments recognize the toxicity levels of agrochemicals in food and soil, they have done little to move away from the use of these products, arguing that fertilizer usage in Africa has not reached undesirable levels.[317]

Taken together, these lock-ins more than constrain individuals, communities, and governments—they drive agrochemical-dependent food systems by aligning incentives, technologies, policies, and narratives in mutually reinforcing ways. Power and resources remain concentrated upstream with the food, fuel, and chemical companies, while risks and costs are shifted onto farmers, fishers, communities, ecosystems, and future generations. The effect is to narrow the space for alternatives even as evidence of harm accumulates.

Understanding these lock-ins as structural—rather than as the aggregated result of individual choices or market failures—is critical for identifying where leverage exists. It directs attention toward the systems of power, incentives, and ideas that sustain agrochemical dependence, and opens space for the kinds of coordinated, systemic interventions that piecemeal approaches cannot achieve. We explore these interventions in the following section.

04

Action Pathways for People and Planet



Photo credit: SELCO Foundation & IKEA Foundation (Global Alliance Member)

Agrochemicals have become a convergence point over the past several years: an opportunity for funders and partners to align strategies across organizations working on health, climate, nature, and food systems; recognize shared objectives; and coordinate toward common goals.

The organizations and initiatives who contributed to this compendium are among the many around the world working to reduce the use of, or phase out, agrochemicals. There is an opportunity now for philanthropy and partners across civil society, farmer and fisher organizations, researchers, governments, and aligned private-sector actors to come together and meet this ambition at scale.

Structural Solutions and Coordinated Action

The impacts and challenges explored throughout this compendium are significant, but there is substantial progress already underway. Across regions, organizations are advancing practical alternatives that reduce agrochemical dependence, strengthen resilience, and address the structural conditions that lock food systems into chemical-intensive production.

Transitioning away from agrochemical-dependant food systems requires coordinated investment across four complementary action pathways:

- Expand the evidence base and reframe narratives;
- Align policy, regulation, and finance;
- Rebalance power and foster accountability; and
- Create enabling conditions for agrochemical transitions.

These pathways are mutually reinforcing: Stronger evidence and more compelling narratives create political space for policy reform. Policy and finance can enable accountability and shift incentives. Greater accountability supports just transitions, while successful transitions generate new evidence, confidence, and momentum for further change.

Equally important is investment in the connective tissue of systems change: the relationships, coalitions, shared infrastructure, and learning networks that enable organizations working across food, farming, climate, biodiversity, health, and toxic pollution to collaborate more effectively. Philanthropy is well positioned to support this coordination by providing long-term and flexible funding, convening diverse actors, and strengthening the partnerships needed for durable transformation.

Together, these efforts can help advance existing international commitments, including the Global Framework on Chemicals (GFC) commitment to phase out highly hazardous pesticides by 2035[318] and the Kunming-Montreal Global Biodiversity Framework target to reduce the risks from pesticides and fertilizers by at least half by 2030.[319] The action pathways that follow identify where coordinated investment can accelerate progress toward these shared goals.

Working Together for Food Systems Transformation

The Global Alliance (GA), together with its members and partners, supports a range of collaborative initiatives to support the transition away from fossil fuel dependence and agrochemical-intensive food systems. These initiatives illustrate several of the action pathways described here while demonstrating how working across sectors can accelerate learning, build political momentum, and mobilize finance for systemic change.

Forging insights on the food–energy nexus: The GA has developed a growing body of work examining the interdependence of food and energy systems, bringing together stakeholders across silos to better understand how fossil fuel dependence shapes agriculture. This includes the 2023 report *Power Shift: Why We Need to Wean Industrial Food Systems Off Fossil Fuels* and its companion *Toward Fossil Fuel–Free Food*, followed by the *Fuel to Fork podcast* in 2024, created with TABLE and IPES-Food. In 2026, the GA and several members contributed to the funder brief *From Poison for Profit to the Power of a United Front: A Funders' Guide to Understanding the Toxic Fossil Economy*, highlighting the shared drivers of the toxic fossil economy and opportunities for coordinated philanthropic action.

Convening funders around chemical pollution: The GA is also a part of a growing number of philanthropic collaborations that offer opportunities for funder education, short-term crisis response, and longer-term food systems resilience, including transitioning away from chemical fertilizers by building soil health, investing in biofertilizers, and ultimately supporting regenerative and agroecological transitions. These include initiatives such as the UK Chemical Pollution Action Funders Alliance; the Global Agrochemical Funders Action Alliance; ChemCure, which has a focus on coordinated action to tackle toxic chemical pollution; and the Super Pollutant Action Alliance, which aims to double philanthropic funding for non-CO_2 climate mitigation, including nitrous oxide pollution.

Connecting agrochemicals and consumption: Given its systems orientation, the GA works with its members to develop coordinated strategies across multiple levers that address ultra-processed foods (UPFs) and intensive livestock production as interconnected parts of the same industrial food system. Commodity crops such as corn, soy, and wheat—grown with intensive pesticide and fertilizer use—feed directly into livestock production while also supplying the cheap starches, oils, and sweeteners on which UPF manufacturing depends.

Aligning funders for regenerative and agroecological food systems transitions (RAFT): The GA brings together philanthropic organizations to coordinate with other capital holders in support of national agroecology strategies and policies, bringing local partners and governments together to strengthen regionally anchored transitions, activate systemic levers and learning, and build the funding architecture needed for regenerative, agroecological food systems. This includes sharing intelligence on potential solutions in light of geopolitical crises and supporting bioinputs assessments, market development, and finance coordination.

Mobilizing philanthropic capital for impact: Beyond grantmaking, philanthropy can use a wider range of financial tools—including mission-related investments, loan guarantees, shareholder engagement, divestment strategies, and higher grantmaking payouts—to accelerate investment in agroecology and regenerative food systems. The GA works with its members to realize the full potential of philanthropic endowments, investment resources, and institutional assets.

Strengthening collective engagement in global governance: The GA supports its members to engage across climate, biodiversity, land, and food governance processes by identifying opportunities arising from global commitments, elevating evidence and policy proposals for systemic change, and supporting frontline food leaders to shape global decisions. This includes participation in the Philanthropic Foundations Mechanism at the Committee on World Food Security and engagement with the Global Alliance Against Hunger and Poverty.

Supporting the True Cost Accounting Accelerator: Launched in 2019, the True Cost Accounting Accelerator is an Allied Initiative of the GA.[320] It aims to strengthen and mainstream True Cost Accounting (TCA) as a tool of choice to guide public- and private-sector responses to food and agriculture challenges, revealing solutions that maximize social, human, and environmental values. This agrochemicals compendium builds on a TCA approach to identify the negative environmental, social, and health impacts and externalities of agrochemical-dependent food and agricultural systems.

Collaborating to address power in food systems: Launched in 2025 and hosted by the United Nations Development Programme, the Food and Power Initiative brings together civil society, academia, UN agencies, international coalitions, governments, and philanthropy to identify, highlight, and challenge power asymmetries in food systems, including those related to agrochemicals. The GA Secretariat are actively participating in the initiative, which aims to advance the right to food, greater equity, and ecological integrity.



Four Action Pathways: An Overview

The following pages provide a high-level overview of the four action pathways. Each pathway is then explored in greater depth.

Pathway 1: Expand the Evidence Base and Reframe Narratives

Evidence is essential for accelerating the transition away from agrochemical-dependent food systems. While the risks associated with agrochemicals are increasingly well documented, contributors to this compendium emphasize the importance of building, communicating, and applying evidence on viable alternatives. Expanding public research, improving transparency, and demonstrating that ecological and regenerative approaches are science-based, economically viable, and capable of delivering environmental, social, and economic benefits can strengthen public confidence and inform more effective policy.

Contributors also stress that dominant narratives have long portrayed chemical-intensive agriculture as modern, efficient, and indispensable, while overlooking the capacity of agroecological systems to deliver productive, resilient, and economically viable food systems.

Shifting these narratives requires not only stronger evidence, but also more effective communication that connects food production with human health, biodiversity, climate resilience, and human rights.

A key part of this shift is moving beyond narrow conceptions of food security based primarily on production. Contributors advocate for narratives that recognize nutrition security, food sovereignty, the right to food, land and seed sovereignty, and ecological resilience as interconnected foundations of sustainable food systems. Framing agroecological transitions through these broader outcomes helps create the political and public support needed for systemic change.

> *In reality, stories about soil health, human health, and biodiversity are narratives about food security—we just need to use clearer, more coordinated messaging to spell out this link.*
>
> **—ClimateWorks Foundation**

Repositioning agroecology and building coordinated civil society advocacy are essential to matching the scale and coherence of industrial agriculture's influence. Contributors call for reclaiming these narratives by elevating agroecology as a modern, science-led, high-return investment—drawing on region-specific success stories and trusted voices, including farmers and scientists, to make the case to policymakers.

Building this shared understanding requires investment in independent science, stronger communication networks, and greater transparency around industry claims. Together, these efforts help create the enabling conditions for the policy reforms, accountability measures, and transitions described in the pathways that follow.

To expand the evidence base and reframe narratives, contributors identified four complementary strategies:

- **1.1** Support public research and mobilize evidence
- **1.2** Connect and protect scientists, journalists, and advocates
- **1.3** Improve transparency and address greenwashing
- **1.4** Reframe food security narratives to uplift nutrition security and resilience



Photo credit: Sudip Maiti, Climate Visuals Countdown, India

Photo credit: Sudip Maiti, Climate Visuals Countdown, India

Pathway 2: Align Policy, Regulation, and Finance

Policy, regulation, and finance play a central role in either reinforcing agrochemical dependence or enabling a transition toward more resilient food systems. Momentum for supportive policies is growing across countries and jurisdictions, while international agreements addressing the triple planetary crises of pollution, biodiversity loss, and climate change—including the Kunming-Montreal Global Biodiversity Framework,[321] the Global Framework on Chemicals,[322] and the COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action[323]—already provide a strong foundation for action. These commitments include reducing pesticide and fertilizer risks, phasing out highly hazardous pesticides, strengthening sustainable nitrogen management, and expanding support for regenerative and agroecological practices.

The challenge is therefore not only to establish new commitments but also to implement and align those already in place. This includes strengthening national regulations, applying the Precautionary Principle, ending the export of pesticides banned in their countries of manufacture, recognizing agrochemicals as central drivers of the climate and biodiversity crises, and ensuring that trade and agricultural policies do not undermine environmental and public health goals.

Public finance must also shift. Subsidies and incentives that support chemical-intensive agriculture, fossil fuel–based inputs, and industrial animal production continue to lock food systems into harmful practices. Repurposing these funds toward soil health, diversified farming, and farmer transition support can reduce risk while strengthening food system resilience and accelerating the transition away from fossil fuel–dependent food systems.

At the same time, governments and private finance partners can work together to contribute to reducing agrochemical dependence by improving disclosure, accounting for environmental and social liabilities, redirecting investment, and supporting transition finance.

True Cost Accounting and polluter-pays approaches can make hidden costs visible and help ensure that financial decisions no longer reward models that transfer health, environmental, and social harms to the public.

To align policy, regulation, and finance, contributors identified four complementary strategies:

- **2.1** Leverage multilateral and regional agreements for action
- **2.2** Repurpose harmful subsidies
- **2.3** Account for the true cost of agrochemicals
- **2.4** Reform private finance for environmental and social resilience

> *As demand for fossil fuels in power and transportation starts to decline, petrochemicals have become an escape hatch for the fossil fuel industry—especially through the expansion of fertilizers and plastics. Exposing these dependencies and challenging false solutions is essential to making space for fossil- and chemical-free food systems.*
>
> **—Lisa Tostado, Center for International Environmental Law**

Pathway 3: Rebalance Power and Foster Accountability

Power in the agrochemical sector is concentrated among a small number of companies that dominate pesticide, fertilizer, and seed markets. This concentration gives industry actors significant influence over prices, research agendas, regulation, narratives, and markets, while limiting space for independent science and agroecological and regenerative alternatives.

Rebalancing this power requires action across multiple fronts. Competition law and stronger market oversight can address consolidation and anti-competitive practices, and create greater space for alternatives. Conflict-of-interest rules can protect regulatory and scientific institutions from industry capture. Greater transparency can reveal how corporate influence shapes public policy, scientific research, and evidence.

Accountability also depends on legal, financial, and civic mechanisms capable of responding to harm. Strategic litigation, tribunals, shareholder engagement, and investor action can expose misconduct, strengthen public scrutiny, and increase pressure on companies to change their practices.

These approaches are most effective when they complement community organizing, policy advocacy, and independent research rather than operate in isolation.

Civil society networks, farmer and fisher organizations, researchers, journalists, Indigenous Peoples, and affected communities are already challenging concentrated power and advancing alternatives. Long-term support for these actors is essential to ensuring that food system decisions reflect the public interest, human rights, and ecological integrity.

To rebalance power and foster accountability, contributors identified four complementary strategies:

- **3.1** Address market distortions and enforce competition law
- **3.2** Regulate industry and disclose conflict of interest
- **3.3** Fund strategic litigation and tribunals
- **3.4** Engage with companies, investors, and shareholders

> *For every corporation or complicit government body, there are thousands of farmers, fishers, workers, Indigenous Peoples, community leaders, and activists demonstrating that a food system grounded in agroecology, food sovereignty, reciprocity, and respect is not only possible, but essential.*
>
> **—Marcia Ishii, Pesticide Action & Agroecology Network North America**



Pathway 4: Create Enabling Conditions for Agrochemical Transitions

For funders and partners investing in climate adaptation, food security, biodiversity, and/or resilient livelihoods, reducing dependence on agrochemicals represents one of the most practical opportunities to strengthen long-term resilience. This requires creating the social, economic, institutional, and market conditions that allow farmers, fishers, workers, and communities to adopt and sustain alternatives without bearing disproportionate risk.

Transitions are already taking place in diverse contexts, supported by farmer- and fisher-led learning, public procurement, ecological pest management, community-controlled bioinputs, territorial markets, and long-term investment. The question is no longer whether reducing agrochemical dependence is possible, but how to support these transitions at the scale and pace required.

Small-scale food producers, peasants, fishers, pastoralists, Indigenous Peoples, workers, forest communities, urban communities, and women, working through networks and organizations like those of the contributors, have articulated a coherent vision for food systems transformation grounded in human rights, local knowledge, and proven agroecological practices. Their leadership should contribute to shaping research, policy, finance, and implementation. Direct investment in these organizations and networks can strengthen their influence in decision-making processes from which they have often been excluded.

Successful transitions require coordinated support across the food system. Farmers need access to knowledge, affordable alternatives, transition finance, secure land and seed rights, and reliable markets.

Workers and communities need protection from exposure and economic disruption. Public institutions can reinforce these efforts through procurement, infrastructure, extension services, and place-based planning.

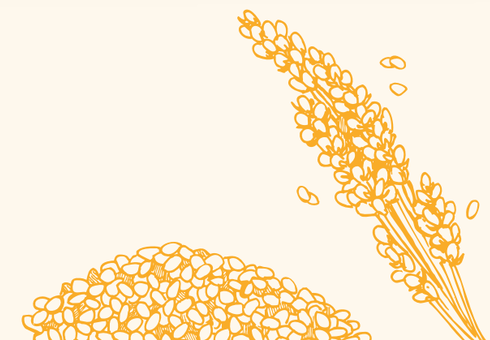
To create enabling conditions for agrochemical transitions, contributors identified eight complementary strategies:

- **4 .1** Support farmer-to-farmer and fisher-to-fisher learning and networks
- **4.2** Safeguard workers and communities
- **4.3** Protect the rights of farmers and fishers
- **4.4** Invest in community-controlled bioinputs and ecological pest management
- **4.5** Build territorial markets, public food infrastructure, and procurement
- **4.6** Promote organic and ecological diets
- **4.7** Fund and de-risk regenerative and agroecological approaches

Taken together, the four pathways reinforce the potential for reducing food systems dependence on agrochemicals: Stronger evidence and narratives create political space for policy reform; policy and finance enable accountability and transition; accountability reduces structural barriers; and successful transitions generate new evidence, experience, and public confidence. Progress in one pathway strengthens the others, while neglecting any one of them can constrain the whole.

The following sections describe practical strategies and examples of work already underway across the four action pathways. They identify opportunities for coordinated investment by philanthropy and partners to support, strengthen, and scale efforts that are already reducing agrochemical dependence and advancing more resilient food systems.

> *Just Transition initiatives are shifting from industrial food systems to food sovereignty and from extractive development toward community rights. Organizing these transitions in a just way is essential to achieving both social and climate justice.*
>
> **—Climate Action Network[324]**



Pathway 1: Expand the evidence base and reframe narratives

1.1 Support public research and mobilize evidence

Redirecting public research away from chemical-dependent agricultural systems toward viable alternatives, while building an independent evidence base, is essential to shifting knowledge systems and narratives. Contributors point to priorities ranging from increased funding for cross-disciplinary agroecological research and substituting inorganic nitrogen with biological fixation[325] to monitoring chemical burdens and pesticide residues.[326]

The McKnight Foundation's Global Collaboration for Resilient Food Systems, for example, has funded agroecological research since the 1980s across three key regions in Africa and South America. Its work demonstrates the effectiveness of biological pest control, bioinputs, integrated pest management,[327] and soil fertility management, while highlighting the importance of scientist–farmer partnerships in reducing agrochemical dependence.

Contributors also point to the 2023 World Health Assembly Resolution, which promotes human biomonitoring systems to track chemical burdens, particularly among children and other vulnerable groups.[328] One example is Salud con Lupa (Health Under a Magnifying Glass), supported by the McKnight Foundation across Peru, Bolivia, and Ecuador.

Working with the Consortium for Health, Environment and Development (Ecosad), the Network of Ecological Agriculture (RAE Peru), and the Agroecological Consortium, the initiative measured pesticide residues in products sold in Peru's six largest supermarkets and communicated its findings through a public awareness campaign, demonstrating how citizen monitoring can strengthen public understanding of pesticide exposure.[329]

1.2 Connect and protect scientists, journalists, and advocates

Connecting scientists, journalists, and advocates is essential to ensuring that emerging evidence on the impacts of agrochemicals reaches the public and policymakers. Pesticide Action Network UK, for example, has established a program in which investigative journalists work closely with researchers to translate scientific findings into policy products while maintaining editorial independence so that findings are driven by evidence rather than predetermined conclusions. The Health and Environment Alliance (HEAL), founded in 2003, connects health researchers and communities affected by agrochemical exposure with policymakers across Europe.[330]

Protecting those who expose impacts and challenge agrochemical industry power is equally important. Contributors call for increased support for investigative journalism and for defending researchers and activists targeted by industry-funded PR firms and surveillance, citing internal corporate documents that reveal deliberate efforts to damage the reputations of journalists and scientists.[331] Industry-funded "impact studies" and lobbying campaigns opposing the EU's pesticide-reduction targets illustrate the same pattern of efforts to influence public debate and policy.[332]

1.3 Improve transparency and address greenwashing

Contributors highlight growing concerns about industry's lack of transparency and greenwashing, particularly efforts to market chemical-intensive production as "regenerative agriculture." Investigative journalists and organizations—including Friends of the Earth, ActionAid, IFOAM - Organics International, IPES-Food, DeSmog, and others—have documented attempts to rebrand chemical-intensive farming as a climate solution.[333]

Greenwashing happens across the supply chain. In its 2022 report *Fossils, Fertilizers, and False Solutions: How Laundering Fossil Fuels in Agrochemicals Puts the Climate and the Planet at Risk,* the Center for International Environmental Law called out fertilizer industry claims that fossil gas–based ammonia produced with carbon capture and storage is "clean,"[334] while a May 2026 report from Friends of the Earth found that almost all regenerative certification schemes, not linked to organic standards, permit widespread agrochemical use in products carrying consumer-facing regenerative labels.[335]

Avoiding new lock-ins—in which subsidies and consumer labelling reward agrochemical-dependent systems marketed as regenerative—requires stronger action from standards organizations, consumer authorities, investors, and donors to scrutinize environmental claims and address greenwashing.

> *In this joint effort to phase out agrochemicals in food production, we applaud the clear focus on transforming rather than just tweaking food systems. This requires both a shift to agroecology, not least organic farming where agrochemicals are excluded, and calling out the misuse of "regenerative" by agrochemical giants trying to re-brand forms of farming with high, and sometimes higher use, of pesticides.*
>
> **—Paul Holmbeck, IFOAM - Organics International**

STRENGTHENING VOLUNTARY SUSTAINABILITY STANDARDS

PAN UK has helped strengthen policies and practices across a range of voluntary sustainability standards and certification schemes—including U.K. supermarkets, Fairtrade International, the Forest Stewardship Council, Better Cotton, and other members of the Integrated Pest Management Coalition of sustainability standards convened by the ISEAL Alliance (formerly the International Social and Environmental Accreditation and Labelling Alliance). This work has improved transparency, aligned these schemes with global goals to reduce harm from chemicals and waste, and reduced pollution risks to biodiversity. PAN UK's technical expertise has also helped several of these initiatives adopt explicit commitments to phase out highly hazardous pesticides (HHPs) while reducing both the toxicity and overall use of pesticides.

In March 2026, the Regen10 Outcomes Framework[336]—which aims to influence regenerative outcomes across half of the world's agricultural land and food production—adopted PAN UK's recommendations on pesticides, including commitments to phase out HHPs at both farm and landscape levels and to reduce reliance on, and minimize the risks from, pesticides and fertilizers. Aligning other regenerative frameworks with these commitments can help ensure that regenerative agriculture delivers meaningful action on agrochemicals rather than simply new sustainability claims.

1.4 Reframe food security narratives to uplift nutrition security and resilience

Understanding food insecurity not simply as a production problem but as an issue of access, entitlement, and distribution is fundamental to reframing food security.[337] Contributors emphasize that shifting the narrative away from agrochemical-dependent production systems requires elevating evidence that demonstrates the resilience and effectiveness of agroecological alternatives.

ClimateWorks Foundation and many others are advancing narratives that position nutrition security, food sovereignty, the right to food, land rights, seed sovereignty, and resilience to climate and economic shocks as interconnected foundations of food security. These contributors emphasize how agroecological farming approaches—including organic and natural farming—protect the ecological functions on which food production depends while delivering positive outcomes for both food and nutrition security compared with systems reliant on agrochemicals.[338]

Contributors stress the importance of challenging assumptions that industrial agriculture is indispensable for feeding a growing population. Contributors, including IPES-Food, ETC Group, GRAIN, Friends of the Earth, IFOAM - Organics International, ActionAid, and Foodrise, point out that industrial food systems divert substantial land and resources toward livestock feed, biofuels, industrial products such as corn-based plastics, and ultra-processed foods rather than produce healthy food for direct human consumption. Reframing food security around quality, equity, and resilience of food systems helps counter claims that continued agrochemical dependence is necessary to ensure global food security.[339]

Politics of Knowledge

In 2021, the Global Alliance for the Future of Food published The Politics of Knowledge: Understanding the Evidence for Agroecology, Regenerative Approaches, and Indigenous Foodways, examining the robust and diverse evidence base for agroecology, regenerative approaches, and Indigenous foodways as pathways to more sustainable, resilient, and equitable food systems.

The report explored five central questions:

1. Can these approaches feed the world?
2. Can they be scaled?
3. Can they provide meaningful livelihoods?
4. Can they address the climate, biodiversity, and soil crises?
5. Can they accelerate food systems transformation?

Bringing together the expertise of dozens of contributors, it found that a narrow view of what counts as evidence, coupled with an entrenched willingness to maintain the status quo, means that these transformative food systems approaches are being kept from being understood, taken up, and acted upon—even when we need them most.



Pathway 2: Align policy, regulation, and finance

2.1 Leverage multilateral and regional agreements for action

A number of conventions, frameworks, treaties, and agreements already include targets to phase out highly hazardous pesticides (HHPs), stop exports of banned pesticides, reduce risks from pesticides and fertilizers, advance sustainable nitrogen management, and support agroecology. Contributors, including PAN UK and PAN International, urge governments and companies to implement these commitments and use them to accelerate national action.[340]

Phasing out Highly Hazardous Pesticides (HHPs)

Target A7 of the Global Framework on Chemicals (GFC) commits governments and the private sector to take measures by 2035 to phase out HHPs in agriculture and make safer and affordable alternatives available. The framework, including target A7, was agreed upon by consensus by a multi-stakeholder coalition of over 100 UN member states and diverse sector representatives and adopted in September 2023 at the Fifth International Conference on Chemicals Management (ICCM5).[341] The formation of a Global Alliance on Highly Hazardous Pesticides (GAHHPs), a multi-stakeholder platform originating from a proposal by 54 African governments, was endorsed at ICCM5. This voluntary and multi-stakeholder initiative invites all relevant actors to become members and work together to achieve the HHP targets of the GFC.

Target 7 of the Kunming-Montreal Global Biodiversity Framework (KM-GBF) mandates governments to reduce the risks from pesticides and fertilizers by at least half by 2030, requiring measurable reductions in the total applied toxicity for pesticides. Both the target and framework were agreed upon by delegates at the UN Biodiversity Conference (COP15) in December 2022. Phasing out HHPs will deliver the significant risk reductions this target requires.[342]

The 2001 Stockholm Convention, an international treaty to eliminate or restrict persistent organic pollutants, has been a critical tool for strengthening controls on some of the world's most hazardous pesticides. Advocates have helped add pesticides to the Convention's Schedule over the years. Most recently, in May 2025, chlorpyrifos, a neurotoxic insecticide, was added to the Convention following years of sustained advocacy by PAN and its partners.[343]

National action builds on these international commitments. Since Sweden became the first country to ban paraquat in 1983, more than 70 countries have followed suit, with Syngenta,[344] historically the world's largest producer of the toxic weedkiller, announcing it was ceasing production by 2026. In March 2026, Telangana State in India introduced a temporary ban on paraquat in response to high levels of pesticide poisoning,[345] and in May 2026 Vermont became the first U.S. state to begin phasing out paraquat.[346]

Stopping exports of banned pesticides

The continued export of pesticides banned from Europe and the United States to countries with weaker regulatory systems remains a major concern. In a campaign launched in 2022, the European Federation of Food, Agriculture and Tourism Trade Unions (EFFAT), together with more than 300 civil society organizations, called upon the European Union to end the production and export of pesticides that are prohibited for use within Europe.[347]

The Rotterdam Convention provides another important mechanism to reduce the export of banned pesticides by requiring Prior Informed Consent before listed hazardous chemicals can be exported, allowing importing countries to refuse HHPs.

Contributors also point to the European Union's One Health approach to antimicrobial resistance, which requires countries exporting animal products to the EU to comply with standards prohibiting the use of antibiotics for growth promotion.[348] Together, these examples demonstrate how trade policy can reinforce global environmental and public health objectives. Contributors emphasize that trade agreements should align with these conventions and targets while ensuring implementation costs are shared equitably across supply chains.

EMBRACING THE PRECAUTIONARY PRINCIPLE

The Precautionary Principle upholds that where an action or policy poses a suspected risk of severe or irreversible harm to people or the environment, protective measures should be taken even where scientific certainty is incomplete.[349] Contributors argue that applying this principle more consistently in regulatory frameworks and trade agreements would strengthen efforts to phase out the most hazardous agrochemicals and shift pesticide governance from managing risks toward preventing harm. They also recommend extending producer responsibility to pesticide manufacturers.[350]



Promoting sustainable nitrogen management

In March 2022, the United Nations Environment Assembly (UNEA) adopted its second resolution on sustainable nitrogen management (Resolution 5/2), encouraging member states to accelerate action to significantly reduce nitrogen waste by 2030 and to develop national action plans.[351] Initially championed by Sri Lanka and sponsored by the governments of Brazil, the Maldives, Pakistan, and Uganda, nearly 100 countries have since designated focal points to support this work.[352] The U.K.'s Sustainable Nitrogen Alliance is one example of how these commitments are being translated into national action, highlighting the potential to reduce the food system's dependence on synthetic fertilizer. It frames this transition as important to food and energy security, with benefits for wildlife, public health, the climate, and farm businesses.[353]

Supporting the transition to agroecology

Contributors emphasize that international agreements increasingly support agroecological transitions, not only reductions in agrochemical use. PAN encourages governments to build on the synergies between the Global Framework on Chemicals and the Kunming-Montreal Global Biodiversity Framework, including commitments to increase support for agroecology and non-chemical alternatives (GFC Target D5) and to expand the application of agroecology (GBF Target 10).[354] These commitments align with the Committee on World Food Security's 2021 policy recommendations on agroecological and other innovative approaches for sustainable agriculture,[355] and with the 2023 COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action, which commits countries to integrating agriculture and food systems into national climate and biodiversity planning.[356]

Boosting Biodiversity Through Agroecology: Guidance for Developing and Updating National Biodiversity Strategies and Action Plans, published in 2024 by the GA, Biovision Foundation, WWF International, Alliance of Bioversity International, and the International Center for Tropical Agriculture, was developed to support countries to do this.

2.2 Repurpose harmful subsidies

Ending the roughly USD 470 billion a year in harmful subsidies[357]—in line with Target 18 of the Kunming-Montreal Global Biodiversity Framework to reduce harmful incentives and scale up positive incentives for biodiversity by 2030—is an important lever for governments advancing food systems transformation. Contributors recommend repurposing public funds to support farmers and fishers transitioning to diversified, agroecological, and organic production systems.

The International Institute for Sustainable Development (IISD), in its 2025 report *Reforming Environmentally Harmful Subsidies: A Playbook,*[358] identifies key pathways for reform, including independent national subsidy assessments, aligning subsidies with food systems transformation goals, and engaging agri-food businesses in environmental and health subsidy reform.[359]

The Agroecology Coalition, a global coalition that brings together more than 50 governments—including major agricultural producers and exporters such as Brazil and Kenya—is building momentum for policy and finance reforms that support agroecology, including calling for conventional agricultural subsidies to be redirected toward agroecological approaches.[360]

Contributors recommend ending incentives that lock in fossil fuel–based agriculture and industrial animal production, including subsidies supporting blue hydrogen and biomethane derived from manure.

REDIRECTING SUBSIDIES TOWARD SUSTAINABLE AGRICULTURE

Governments are already beginning this shift. For example, supported by the Global Environment Facility of Conservation International, a new government pilot in Fiji will incorporate organic fertilizer alternatives into an existing national fertilizer subsidy, with the aim of improving soil health, reducing agricultural runoff, and supporting farmers.[361] South Korea's Environmentally Friendly Direct Payment Program, introduced in 1999, supported approximately 426,000 hectares of farmland to transition by 2010.[362] Accounting for 25 percent of total farmland, the program demonstrates that this approach can operate effectively at scale.

2.3 Account for the true cost of agrochemicals

True Cost Accounting (TCA) is an economic framework to account for the environmental, social, and health outcomes of different food systems and practices, including impacts that are often hidden or externalized. As a tool, TCA enables policymakers, investors, and businesses to objectively compare the costs and benefits of agrochemical-dependent and agroecological food systems, and make appropriately informed decisions. Contributors argue that once these costs are recognized, they should be internalized through taxation and polluter-pays policies rather than shifted onto workers, communities, public health systems, and ecosystems.

PAN, Friends of the Earth, Foodrise, and EFFAT support measures such as an EU-wide pesticide sales tax calibrated to pesticide risk as a practical application of the polluter-pays principle and an incentive for producers, users, and consumers to reduce their dependence on hazardous pesticides.[363]

Denmark's toxicity-based pesticide tax provides one example, contributing to a 16 percent reduction in pesticide toxicity during the four years following its introduction in 2013.[364]

Contributors identify additional mechanisms for internalizing external costs, including windfall taxes on agribusinesses that profit from market shocks, formal recognition of pesticide-linked occupational diseases, and mandatory emissions reporting by the fertilizer industry in line with Paris Agreement commitments.[365]



2.4 Reform private finance for environmental and social resilience

Reforming finance flows from institutional and private investors is essential to ending the structural subsidy that capital markets currently provide to chemical-intensive food systems. Institutional investors are increasingly examining whether agrochemical companies should remain in their portfolios and are considering divestment[366] or shareholder engagement in response to governance failures, information suppression, and growing reputational risks.[367]

Contributors propose several strategies to redirect financial flows, including stronger environmental, social, and governance (ESG) requirements, climate-related financial disclosures for agrochemical investments, transition finance that de-risks the shift from chemical-intensive to agroecological production over three- to five-year periods, and debt relief for low-income countries to free capital for just transitions.

CIEL's *Toxic Finance* report advocates for private banks to end financing for petrochemical expansion—including new plastics, fertilizer, pesticide, and chemical feedstock facilities—and require companies that have received such financing to develop and publicly disclose credible 1.5°C-aligned transition plans.[368]

Pension funds and insurers are recognizing that continued investment in chemical-intensive food systems increases exposure to interconnected climate, biodiversity, and public health risks. New York City's three public pension funds (NYCERS, TRS, and BERS) divested from fossil fuel reserve owners in their public equity portfolios beginning in 2018, completed the process in 2022, and in 2024 proposed extending exclusions to midstream and downstream fossil fuel infrastructure as part of their broader Net Zero Implementation Plans.[369]

To provide investors with practical tools, Adasina Capital worked with contributors ETC Group and Friends of the Earth to develop an Extractive Agriculture Screen.[370] Philanthropic foundations likewise have an opportunity to align both endowment investments and program-related investments with agroecological transitions through divestment, mission-aligned investing, and shareholder advocacy.

> *So long as powerful interests profit from the current food system, they will have no incentive to transform it—making people-centred action and structural reform of finance a political as much as a technical challenge.*
>
> **—Jennifer Clapp, University of Waterloo**



Pathway 3: Rebalance Power and Foster Accountability

3.1 Address market distortions and enforce competition law

Addressing market distortions and enforcing anti-trust law to reduce concentration in the seed, pesticide, and fertilizer sectors is essential to rebalancing power in food systems and creating space for viable alternatives. Contributors including ETC Group, GRAIN, and IPES-Food highlight the accelerating consolidation of the agrochemical sector and how it suppresses competition and limits opportunities for agroecological innovation.[371]

To strengthen competition policy, the Shamba Centre for Food & Climate recently launched the Advisory Centre for Competition Law & Policy in Africa jointly with the Centre for Competition, Regulation and Economic Development, with support from the Common Market for Eastern and Southern Africa, the East African Community, the Economic Community of West African States, the African Continental Free Trade Area, and several African competition authorities.[372] Supporting this type of research and regulatory capacity can help expose market distortions, strengthen competition policy, and create space for agroecological alternatives to flourish.

3.2 Regulate industry and disclose conflict of interest

Closing the revolving door between industry and regulatory agencies, academia, and food governance bodies, together with implementing stronger conflict-of-interest rules, can restore confidence in agrochemical regulation.[373] Contributors including PAN UK and AFSA advocate for greater structural separation between regulators and industry,[374] including prohibiting industry representatives from serving on pesticide assessment committees, consistent with UNICEF guidance that public policy and normative processes should be free from food and beverage industry conflicts of interest.[375]

Contributors also highlight successful efforts to challenge corporate influence in global food governance. PAN, FIAN, and allied civil society organizations mobilized to expose a formal partnership FAO announced with CropLife International in 2020, raising concerns about corporate influence over global decision-making.[376] In the wake of this organizing, the FAO announced the end of the partnership three years later. IPES-Food and Foodrise are just two of several organizations advocating for stronger disclosure requirements in scientific publishing, greater public investment in independent research, and stronger accountability for corporations that shape scientific evidence and public discourse in defence of harmful products.[377] Together, these measures can strengthen transparency and ensure that regulatory decisions better reflect the public interest.

3.3 Fund strategic litigation and tribunals

Strategic litigation has become an important tool for holding agrochemical companies accountable. Legal challenges against pesticide manufacturers have resulted in multi-billion-dollar settlements, significant market losses, and the disclosure of internal company documents that have reshaped public understanding of industry practices.[378] Contributors note that while litigation outcomes fall short of covering the full costs borne by affected communities or public health systems, they have increased corporate accountability and public scrutiny.

USING STRATEGIC LITIGATION TO ADVANCE ACCOUNTABILITY

Bayer paid over USD 11 billion to settle thousands of cases related to Roundup between 2020 and 2025,[379] as well a class action settlement of USD 7.25 billion in 2026.[380] Along with Syngenta's paraquat-related proposed settlement agreement,[381] these settlements mark some of the largest agrochemical-related litigations to date.

In 2023, ClientEarth and Lipu-BirdLife successfully challenged agrochemical pollution from intensive hazelnut production that threatened central Italy's Lake Vico, the principal drinking water source for surrounding communities.[382] In 2012, Sofía Gatica and the Mothers of Ituzaingó won the first successful Latin American case concerning pesticide pollution after organizing the families of neighbourhoods surrounding Córdoba, Argentina's second-largest city, affected by aerial pesticide spraying.[383]

Alongside formal litigation, contributors highlight people-centred accountability mechanisms such as citizens' juries and opinion tribunals. In 2011, the Permanent People's Tribunal, working with PAN International, convened a three-day tribunal in India that examined the conduct of the world's six largest pesticide companies and the governments of the United States, Switzerland, and Germany, documenting alleged violations of the rights to life, health, and livelihood.[384]

More recently, the Seeding Reparations Collective in the U.K. has been working to advance reparations-focused approaches to food systems transformation, including tribunals that address the enduring impacts of European colonialism and agrochemical dependence.[385]



3.4 Engage with companies, investors, and shareholders

A growing number of businesses and private-sector sustainability initiatives are aligning with global climate, biodiversity, and Sustainable Development Goals (SDG), however implementation continues to lag behind public commitments. A 2026 assessment by the World Benchmarking Alliance, a nonprofit organization that assesses and ranks the world's most influential companies on their contribution to the SDGs, found that while 17 percent of food and agriculture companies had established soil health targets, only 8 percent disclosed information on pesticide and fertilizer use, and just 5 percent reported measurable improvements in soil health.[386]

Working with companies and industry initiatives to establish targets for improving soil health, reducing pesticide toxicity, improving nutrient-use efficiency, and reducing overall agrochemical dependence represent important opportunities to build more resilient food systems.

Practical tools are already available, including the Biovision Foundation for Ecological Development's B-ACT tool[387] and the Agroecology Coalition's Finance Assessment and Tracking Tool,[388] which help identify and assess agroecological enterprises and initiatives. Investor interest in regenerative agriculture is also increasing. Contributors caution, however, that some investment continues to support forms of "regenerative" production that remain dependent on agrochemicals. They argue that investors can play a more transformative role by directing capital toward organic and agroecological systems that reduce chemical dependence, strengthening engagement with companies, and supporting implementation of global biodiversity and chemical commitments.

> *To align with evolving priorities, the industry must incorporate "least harm principles," ensuring its business model prioritizes environmental stewardship and resource conservation while maintaining food security and addressing how fertilizer production impacts emissions.*
>
> **—Regenerative Agriculture Foundation and McKnight Foundation**

The move to mobilizing the financial sector around environmental, social, and governance (ESG) risks associated with agrochemical-dependent food systems is gaining momentum. FAIRR, ShareAction, Ursa Collective, and other organizations are engaging investors and shareholders through shareholder resolutions, corporate engagement, and related accountability strategies to make the financial risks of agrochemical dependence more visible and encourage changes in corporate behaviour.

INVESTOR ACTION ON HAZARDOUS CHEMICALS

An investor initiative on hazardous chemicals led by ChemSec, an independent nonprofit organization that advocates for safer alternatives to toxic chemicals, is one example of this approach. The initiative coordinates more than 75 investors representing over USD 23 trillion in assets under management in ongoing engagement with the world's largest publicly traded chemical companies.[389] In addition, ChemSec, along with ShareAction and others, have supported more than 44 institutional investors representing over USD 4 trillion in assets to urge agrochemical companies to phase out highly hazardous chemicals, strengthen biodiversity disclosures, and align their strategies with the Kunming-Montreal Global Biodiversity Framework and the Global Framework on Chemicals by transitioning product portfolios toward safer and more sustainable alternatives. [390]



Pathway 4: Co-create enabling conditions for agrochemical transitions

4.1 Support farmer-to-farmer, fisher-to-fisher learning and networks

ESAFF, ActionAid, FIAN, AFSA, the McKnight Foundation, IFOAM - Organics International, and PAN Asia Pacific are among the contributors supporting peer-to-peer learning, farmer research networks, farmer field schools, and farmer–scientist collaborations to accelerate community-led transitions away from chemical-intensive food systems.

FACILITATING PEER-TO-PEER EXCHANGES ON POLICY AND ADVOCACY

Contributor IFOAM - Organics International has trained more than 2,500 organic and agroecological leaders in advocacy, policy, leadership, and food systems analysis through its global academy, with more than two-thirds going on to become trainers.[391] Working with global and local partners, the Academy is expanding its focus on national organic and agroecology policy, advocacy, and market access for smallholder farmers by strengthening communities of practice, facilitating the exchange of best practices, and building the capacity of frontline organizations to shape policy and market systems.

Food Policy Forum for Change—launched in October 2020 by the Biovision Foundation, in collaboration with IFOAM - Organics International, the Millennium Institute, and with technical support from the FAO—supported an interactive global network connecting policymakers and advisers for peer-to-peer learning on sustainable, agroecological food systems through access to community-driven coaching, regional and international champions, experts, case studies, tools, and evidence.[392]

These approaches recognize farmers and fishers as co-producers of knowledge rather than passive recipients of technical advice. By embedding ecological knowledge within communities, farmer- and fisher-led networks enable innovations to spread through trusted local relationships rather than relying solely on top-down extension services.[393] For example, the World Forum of Fisher Peoples brings together fisher leaders to share experiences at their general assemblies and supports peer-to-peer exchanges on thematic issues.

At their 2024 assembly, youth peer-to-peer sessions were organized to share strategies for overcoming obstacles and sustaining their livelihoods as fisher peoples.[394]

The Agroecology Coalition and a number of funders—particularly the Agroecology Fund, a pooled donor collaborative—support this peer-to-peer learning exchange by directing grants to grassroots agroecology movements, including smallholder farmer and fisher organizations.

The same principles of peer-to-peer exchange and learning underpin Participatory Guarantee Systems (PGS), an alternative to third-party certification in which farmers and fishers work together to develop, monitor, and verify shared production standards.[395]

Worldwide, approximately 1.4 million producers are involved in PGS that, in addition to lowering certification costs, strengthen peer learning, knowledge exchange, trust-based accountability, and market access, enabling producers who might otherwise be excluded from premium markets to adopt and benefit from more sustainable production systems.[396]

4.2 Safeguard workers and communities

Protecting agricultural workers and communities from agrochemical exposure requires enforceable environmental and occupational health standards paired with meaningful compensation and remediation for those already harmed. This includes ensuring that companies are accountable not only for preventing harm but also for addressing adverse impacts throughout their supply chains.

The EU's Corporate Sustainability Due Diligence Directive, which was enacted in 2024, establishes this principle by requiring companies to identify, prevent, and address actual and potential human rights and environmental impacts across their operations, subsidiaries, and business relationships, and to provide remediation where harm has occurred.[397]

> *Agrochemicals are one of the major occupational risks in agriculture. Prevention must be given the highest priority, including the elimination of risks through reducing the use of pesticides and just transitions to less harmful alternatives. Where prevention comes too late, there must be proper recognition and compensation for workers who fall ill due to exposure to pesticides. Workers should have the right to receive a certificate containing the agrochemicals used during their professional activities, to facilitate the recognition of occupational diseases.*
>
> **—Ivan Ivanov, European Federation of Food, Agriculture and Tourism Trade Unions (EFFAT)**

In practice, however, its application to agrochemical companies remains largely untested. For example, a 2024 complaint against Bayer over glyphosate-related harms in South America, filed under Germany's parallel supply chain law, took more than two years to resolve and was ultimately dismissed by regulators, highlighting the gap between the law's remediation provisions and enforcement in practice.

Contributors highlight the important role of grassroots and civil society organizations in advancing practical protections for workers and communities affected by agrochemicals. PAN UK has worked with local councils in the U.K. to establish pesticide-free towns,[398] while PAN North America has supported campaigns to strengthen protections for California farmworkers, including buffer zones from communities, protective safety gear for workers, protection from heat exposure, and representation on advisory committees to the Department of Pesticide Regulation.[399]

EFFAT is campaigning for workers to have the right to know which agrochemicals they have been exposed to and for Parkinson's disease linked to pesticide exposure to be formally recognized as an occupational disease across the European Union.[400] The Health and Environment Alliance has supported platforms for communities affected by pesticide poisoning, including France's Pesticide Victims Compensation Fund, which combines clinical care with compensation and is being promoted as a model for wider adoption across Europe.[401] In India, Self Employed Women's Association's (SEWA) Agriculture and Clean Skies campaigns have been building farmer awareness of the right to a clean and healthy work environment while supporting transitions to natural farming, multi-cropping, and soil nutrient management.[402]



Levels of Food System Change

Food system change happens at different scales and over different timelines, depending on a variety of factors. A just transition toward agroecology and away from agrochemicals requires participation from, and partnership with, food producers, workers, and consumers. Even in times of crisis, when the focus is on short-term incremental changes, there is a need to invest in and support long-term resilience and equitable food systems.

Developed by Professor Stephen Gliessman (University of California, Santa Cruz) in 2016, the five-level framework for transition toward sustainable food systems recognizes that transformation occurs through multiple, interconnected levels of action. It distinguishes incremental changes at the farm level from broader system-level transformations that reshape markets, policies, institutions, and the relationships between food systems and society.

TRANSFORMATIONAL

LEVEL 5
Build a new global food system based on participation, localness, fairness, and justice

LEVEL 4
Reconnect consumers and producers through the development of alternative food networks

LEVEL 3
Redesign agroecosystems

INCREMENTAL

LEVEL 2
Substitute conventional inputs and practices with agroecological alternatives

LEVEL 1
Increase efficiency of input use and reduce use of costly, scarce, or environmentally damaging inputs

4.3 Protect the rights of farmers and fishers

> *Our incessant exposure to toxic substances from a multitude of sources directly implicates our human rights to life. It prevents us from reaching the highest attainable standard of health. Exposure to toxics also blocks access to physical integrity, to safe water and food, to adequate housing, and—in an increasing number of States—the right to a healthy environment.*
>
> **—UN Special Rapporteur on Toxics and Human Rights Foundation**

Rights-based frameworks serve to protect the most vulnerable farmers and fishers in a context where they are most impacted. Securing land and water tenure and customary rights for small-scale producers and Indigenous Peoples is fundamental to agroecological transitions. Without secure rights, farmers and fishers have limited ability to move away from agrochemical-dependent production systems. Equally important is seed sovereignty—the right to save, use, exchange, and sell diverse, locally adapted seed varieties—which underpins agroecological practices and stands in direct tension with proprietary seed systems tied to chemical inputs. Women farmers and smallholders, who are both disproportionately affected by agrochemical dependency and central to conserving agricultural biodiversity, have the greatest stake in securing these rights.[403]

In line with the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries,[404] contributor World Forum of Fisher Peoples (WFFP) advocates for the rights of small-scale and artisanal fishers, defending customary rights over water and coasts, and advancing alternatives rooted in food sovereignty.[405] The WFFP calls for agrochemical research and policy to expand beyond terrestrial agriculture to examine the impacts of various chemicals, including antibiotics, pesticides, and ammonia used in aquaculture, which have received far less attention than pesticide use on land.[406]

HUMAN RIGHTS–BASED FRAMEWORKS

Since its founding in 1986, contributor FIAN has worked with partners to ensure that a just transition centres marginalized groups facing multiple and intersecting forms of discrimination and exclusion, while guaranteeing their meaningful participation in decision-making. Its work is rooted in securing rights to land, water, seeds, food,[407] a clean, healthy and sustainable environment,[408] protection from climate change,[409] and participation, as recognized in the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas (UNDROP)[410] and the UN Declaration on the Rights of Indigenous Peoples (UNDRIP).[411] These frameworks guide member states in implementing their obligations under international human rights covenants.[412]

Agroecology both respects and strengthens these rights by creating space for alternative food systems rooted in cooperation, solidarity, and ecological stewardship. FIAN is also part of a civil society coalition advocating for a binding Treaty on Business and Human Rights through the Open-ended intergovernmental working group on transnational corporations and other business enterprises with respect to human rights.[413] The coalition calls for businesses and governments to adopt and implement territorial and extraterritorial liability mechanisms for agrochemical-related harms, including strict liability for highly hazardous pesticides.

4.4 Invest in community-controlled bioinputs and ecological pest management

Supporting locally driven, decentralized, and contextually relevant production of biofertilizers and biopesticides is a key strategy for reducing dependence on expensive, proprietary agricultural inputs.[414] GRAIN emphasizes that an agroecologically rooted approach to bioinputs is essential to ensuring these alternatives serve farming communities rather than corporate interests.[415]

Greater investment in independent biological pest control research and non-chemical pest management is needed, alongside safeguards against the co-option of bioinputs by major agrochemical companies seeking to expand their product portfolios.[416] This includes tracking acquisitions of independent biofertilizer and biopesticide companies, scrutinizing corporate "biologicals" marketed as complements to—rather than replacements for—synthetic inputs, and attaching conditions such as open licensing or non-exclusive access to publicly and philanthropically funded research to prevent publicly funded innovations from being patented or acquired by dominant firms.

While cost can be a barrier to scaling community-owned bioinputs, contributors identify regulation as an even greater challenge. A 2025 review of biopesticide regulation across six Southern African countries found that biological products are typically regulated through frameworks designed for chemical pesticides. Burdensome registration costs and underdeveloped regulatory guidance create significant barriers for local, small-scale producers, regardless of investment in production capacity.[417]

Biological and agroecological alternatives deliver effective pest control under real farming conditions.

—African Center for Biodiversity

INVESTING IN BIOLOGICAL ALTERNATIVES

The McKnight Foundation's Global Collaboration for Resilient Food Systems supports participatory, farmer-led research on botanical pesticides, integrated pest management, and legume-based soil fertility management, helping build the evidence base for biological alternatives.[418]

The Heinrich Böll Foundation supports agrochemical transitions in Africa, where it advocates for a complete phase-out of fossil fuel–based nitrogen fertilizers through the use of cultivation practices to improve soil fertility, including the prioritization of biofertilizers and diversified farming systems. The foundation argues that so-called "green" hydrogen-based fertilizers should, if used at all, serve only as temporary measures in nitrogen-deficient situations to avoid creating new forms of dependence on synthetic fertilizers.[419]



4.5 Build territorial markets, public food infrastructure, and procurement

Public food infrastructure and procurement create an enabling environment for territorial markets that protect traditional diets or support dietary transitions away from ultra-processed, agrochemical-dependent commodity chains. By prioritizing local procurement, governments and public institutions can strengthen decentralized storage, processing, cold-chain, and renewable energy infrastructure that enables local and agroecological producers to reach consumers through shorter, more resilient supply chains while normalizing healthier diets.

Many jurisdictions have already legislated local food procurement. France's 2018 Egalim Law requires that meals served in public collective catering include 50 percent of products meeting specific quality and sustainability criteria, with at least 20 percent organic.[420] Italy's 2017 Fund for Organic School Canteens has similarly promoted and expanded organic sourcing in public institutions.[421]

In 2024, Mexico's school meal strategy, coordinated through the National System for the Comprehensive Development of the Family across 32 state-level programs, set a target of purchasing at least 30 percent of food from local producers, particularly smallholder farmers, and aligning meals with regional culture and food traditions while promoting regional economic development.[422]

In the United States, the Good Food Purchasing Program, first adopted by the Los Angeles Unified School District in 2012, encourages institutions to commit to equity, transparency, and accountability in their food purchasing and to direct their purchasing in service of five core values: local economies, environmental sustainability, a valued workforce, nutrition, and animal welfare.[423] As of 2026, the program works with hundreds of organizations in more than 39 cities and counties across the country, collectively spending over USD 1.2 billion on food each year.[424]

BRAZIL'S NATIONAL SCHOOL FEEDING PROGRAM

Brazil's National School Feeding Program allocates 45 percent of procurement funds to food purchased from family farmers, with priority given to local producers, agrarian reform settlers, and Indigenous and Quilombola communities.[425] The program pays premium prices for organic and agroecological produce. With an annual budget exceeding USD 1 billion, the program demonstrates how public procurement can simultaneously create stable markets for smallholders, improve child nutrition, shorten supply chains, and strengthen local food systems. Recent reforms also set targets to reduce processed and ultra-processed foods to 10 percent of school food purchases.[426]

4.6 Promote organic, ecological diets

The enabling conditions described here—public procurement, territorial markets, and decentralized food infrastructure—can improve both health and environmental outcomes when they support organic and agroecological diets in addition to local or plant-based targets. Research supports the case for dietary transition, with evidence that an organic diet can reduce pesticide exposure.[427] Friends of the Earth's peer-reviewed "Organic for All" study of American families found that switching to a fully organic diet reduced pesticide levels in the body by an average of 60.5 percent within six days.[428]

Contributors highlight the importance of linking movements for sustainable diets with sustainable agriculture so that shifts toward plant-based eating also support production systems that reduce agrochemical dependence. Foodrise has been campaigning for a transition toward plant-based diets that will reduce nitrogen fertilizer inputs and increase nitrogen use efficiency.[429] Legumes, for instance, provide the co-benefit of plant protein, fibre, nutrition, and biological nitrogen fixation while also having a higher nitrogen use efficiency than animal-based protein sources.[430]

Campaigns such as Ultra-Processed Animals (UPA), developed by the Jeremy Coller Foundation, draw attention to the impacts of industrial livestock production on animal welfare, human health, and the environment.[431] In the United Kingdom, the Soil Association is campaigning to phase out industrial chicken from school and hospital menus, prohibit new intensive poultry units, and support farmers transitioning to agroecological and higher-welfare systems, including organic production.[432] In several countries across Sub-Saharan Africa, locally sourced fish supplied by small-scale fishers are increasingly recognized as an important component of school food and nutrition programs.[433]

TRANSLATING ADVOCACY INTO PUBLIC INVESTMENT

In 2023, advocacy by plant-based and organic organizations in Denmark, together with partners across the climate, health, farming, and environmental movements, led to the creation of a government Plant-Based Food Grant to support the development of plant-based products, markets, and consumption. Of the USD 198 million in available funding, at least 50 percent of the funds are earmarked for organic plant-based initiatives to lower agrochemical use.[434] Building on this success, the Danish Vegetarian Society and its partners launched Danish Plant-Based Diplomacy, which brings together organizations and policymakers across Europe and beyond to share lessons on policy development, advocacy, and coalition-building.[435] The initiative works closely with IFOAM - Organics Europe and other partners to advance an EU Action Plan for organic plant-based foods by strengthening collaboration among organic, agroecological, and plant-based movements.

4.7 Fund and de-risk regenerative and agroecological approaches

Scaling agroecological transitions requires a significant shift in how food systems are financed. Contributors emphasize that one of the greatest barriers is not the long-term viability of agroecological production but the financial risks producers face during the transition away from agrochemical use. Philanthropic grants, program-related investments, and impact investments can play a catalytic role by de-risking this transition and unlocking larger flows of public and private capital.

In 2023, the GA brought together 25 leading philanthropies and issued a joint call for a tenfold increase in funding flows to regenerative and agroecological food systems, from current levels of roughly USD 44 billion to an estimated USD 250 to 430 billion annually.[436] Over the last three years, GA members and partners supported planning partnerships in six countries to identify transition priorities, developed a collaborative finance and action model that strategically links investment flows across capital holders, and are making investments to support transitions in six countries.[437] This is illustrative of the broader momentum and action around the world to support regenerative and agroecological transitions.

BRIDGING THE TRANSITION FINANCE GAP

A critical and often overlooked gap in transitions to organic or agroecological farming is the transition period itself. Standard organic certification requires a minimum three-year transition window with no use of prohibited synthetic inputs. Some soil science estimates put genuine recovery of soil microbial and biodiversity function at five to seven years. During this extended window, farmers face a direct financial penalty: They must absorb the higher costs and potentially lower yields while still unable to access the price premiums that organic certification eventually unlocks. Conventional agricultural lending is poorly suited to this gap, since most loan products are underwritten against current yield and revenue, not a multi-year transition trajectory. This is precisely where bridge financing is needed, and where philanthropy can lead to catalyze shifts in formal credit markets.

The growth of organic markets demonstrates that, alongside policy advocacy, supportive finance and market development can create durable incentives for reducing agrochemical dependence. Valued at approximately USD 169 billion globally, the organic market provides improved income opportunities for an estimated 4.8 million organic farmers while creating sustained demand for production systems that avoid synthetic agrochemicals.[438] The organic experience illustrates how investment can help farmers navigate the transition while building long-term market demand for agroecological production.

Governments also have an important role in de-risking transition. A range of countries, particularly in the EU, provide support for farmers converting to organic production through mechanisms including direct conversion payments, tax credits, and support for certification costs. France, for instance, has a dedicated organic farming tax credit to offset income loss during transition periods.[439]

Contributors identified practical opportunities for philanthropic investment. Given the current fertilizer crisis, one immediate priority is supporting the exchange of knowledge on biological alternatives that reduce fossil fuel dependence, chemical pollution, and input costs for farmers. Philanthropic institutions can help unlock broader investment shifts not only by supporting transition finance mechanisms but also by evaluating whether agrochemical companies should remain in their investment portfolios.

SCALING POLICY AND MARKET APPROACHES

IFOAM - Organics International works to share best practices in policy, market access, supply chain development, and consumer mobilization across borders. It also works closely with actors in the agroecology movement on advocacy at the national, regional, and global levels, transferring lessons from National Organic Action Plans to the development of national agroecology strategies. IFOAM, and its 663 member affiliates from more than 120 countries, have also played a leading role in developing Participatory Guarantee Systems and Organic Grower Group Certification, making organic assurance systems more accessible and affordable for smallholder agroecological farmers, particularly in the Global South.[440]

Together, these policy, market, and financing approaches demonstrate that well-designed public, philanthropic, and private investment can accelerate the transition from agrochemical dependency to organic and agroecological food systems.



Photo credit: Georgina Smith, CIAT, Cambodia

Breaking Through the Lock-Ins: Agrochemical Transitions in Practice

The Global Alliance (GA), together with its members and partners, supports a range of collaborative initiatives to support the transition away from fossil fuel dependence and agrochemical-intensive food systems. These initiatives illustrate several of the action pathways described here while demonstrating how working across sectors can accelerate learning, build political momentum, and mobilize finance for systemic change.

Input dependence reduced: In southern Mali, participatory research found that locally adapted maize–cowpea intercropping and livestock integration reduced the need for external synthetic inputs while increasing gross farm margins by 20 to 26 percent without compromising household food self-sufficiency.[1] Since 2022, Practical Farmers of Iowa has led a successful nitrogen-reduction program that has helped farmers in the region cut 1.6 million pounds of synthetic nitrogen fertilizer use. The organization's soil-health programs supported more than 2,400 farmers planting cover crops across over nearly 1 million acres, helping demonstrate how farmer-led approaches can reduce costly inputs while maintaining productive farms.[2]

Farmer-led transitions scale: Andhra Pradesh Community-Managed Natural Farming (APCNF) demonstrates what becomes possible when farmer knowledge and peer-to-peer learning are supported at scale. Since its launch in 2015–16, the program has expanded to more than 1.77 million farmers and nearly 1 million hectares, replacing synthetic chemicals with locally produced biological inputs and ecological pest management. Reported results include farmer income gains of 38 to 66 percent, water savings of up to 50 percent, and greenhouse gas emission reductions of up to 46 percent per acre.[3]

Soils, landscapes, and resilience restored: Farmer-Managed Natural Regeneration has supported over 600,000 smallholder farming households, covering nearly 1 million hectares of land across 8 African countries in Africa's Sahel region to adopt and refine diverse, appropriate, and profitable regreening practices,[4] resulting in millet yields increases of over 100 percent and approximately 5 million hectares of once-degraded farmland now supporting medium to high densities of tree cover.[5] After Hurricane Mitch in Central America, agroecologically farmed plots suffered less surface erosion than conventional plots, including 58 percent less damage in Honduras, 70 percent less in Nicaragua, and 99 percent less in Guatemala.[6]

In Benin, an organic cotton initiative has reached more than 9,000 smallholders. The transition increased farm profitability by 65 percent, produced 75 percent higher mean soil organic carbon than conventional fields, and increased soil biological activity and soil microorganisms while eliminating acute pesticide poisonings.[7]

Women and young farmers as agents of change: In Malawi, women comprise 56 percent of the 164,000 members of the National Smallholder Farmers' Association. The organization has found that focusing on women and youth has facilitated the transition to agroecological practices.[8] In Andhra Pradesh, more than 3.5 million women organized into roughly 340,000 Self-Help Groups provide community infrastructure for the transition from chemical-based agriculture to natural farming.[9] These experiences demonstrate how women's leadership and community networks can accelerate adoption and sustain transitions at scale.

Policy and local governance shift incentives: Public procurement is a powerful tool for creating markets. Brazil requires at least 30 percent of school food procurement from family farms,[10] supporting 120,000 smallholders,[11] while U.S. initiatives such as the Centre for Good Food Purchasing are advancing procurement of pesticide-free food, as the organic market heads toward a projected USD 100 billion by 2030.[12]

In coastal Tamil Nadu, India, fishing communities have mobilized Panchayats (village councils) to reject polluting factory fish farms and protect mangroves, breeding grounds, and traditional fishing rights.[13]

Transitions strengthened through social infrastructure: Farmer networks and community institutions help knowledge spread and practices adapt to local conditions. In Indonesia, for example, farmer field schools were introduced in response to pest resurgences linked to pesticide resistance; by 2002, more than 1 million farmers had participated, reducing agrochemical expenditures while restoring rice yields.[14] Zimbabwe Smallholder Organic Farmers' Forum program's farmer field schools, seed festivals, traditional seeds, and peer support networks have helped farmers maintain harvests through severe climate shocks while eliminating synthetic input costs.[15] Infrastructure for agroecological learning is also expanding globally, through IFOAM's international leadership training, growing agroecology networks in the United States, and new university-based institutions dedicated to agroecological research, education, and practice—including the first agroecology institute at a U.S. land-grant university.[16]

1 Falconnier et al., Co-Learning Cycles to Support the Design of Innovative Farm Systems in Southern Mali, 2017.
2 Practical Farmers of Iowa, N Rate Risk Protection Program. Accessed October 2026
3 Rythu Sadhikara Samstha, Andhra Pradesh Community Managed Natural Farming. Accessed October 2026.
4 Landscape Alliance, About Regreening Africa. Accessed October 2026.
5 Landscape Alliance, Niger's Re-Greening Revolution. Accessed October 2026.
6 Edwin Escoto and Steve Brescia, Honduras: Building a National Agroecology Movement Against the Odds, 2017.
7 PAN UK, Cotton in Benin, West Africa, 2025.
8 NASFAM, Principles Guiding New Investments in Agriculture: Fostering Gender Balance and Women's Empowerment, 2023.
9 Deepika Amirapu, From Drought & Debt to 2026 Food Planet Prize: Inside Andhra's Women-Led Natural Farming Revolution, 2026.
10 Programa Nacional de Alimentação Escolar, National School Feeding Program. Accessed October 2026.
11 FAO, The Brazilian School Feeding Model, 2014.
12 US Organic Trade Association, U.S. Organic Marketplace Achieved Significant Growth in 2025, 2026.
13 FIAN, Impact of Shrimp Aquaculture on Fisherpeoples' Right to Food and Nutrition in India, 2023.
14 PANNA, Pesticide Action Network: The First 30 Years, 2012.
15 ZBC News, Govt Makes Inroads with the Implementation of Agroecology, 2024.
16 University of Vermont, What Makes the Institute for Agroecology Unique? Accessed October 2026.

Conclusion

Recent breakthroughs in global recognition of organic farming, agroecology, and truly regenerative approaches as part of the solution to climate change, food and nutrition insecurity, fossil fuel dependence, and biodiversity loss provide an unprecedented opportunity to accelerate food systems transformation. The IPCC's *Sixth Assessment Report* (Working Group II, 2022) marked a turning point in this recognition, identifying agroecology as a strategy that contributes to both climate mitigation and adaptation while cautioning against "maladaptation"—the risk that short-term technical fixes, such as capital-intensive irrigation or glyphosate-based no-till systems, ultimately aggravate the very vulnerabilities they aim to solve.[441]

Seizing this opportunity and bringing agroecology to scale around the world requires strong organizations capable of both challenging corporate concentration of power across policy and market systems and building the structures and systems needed for food systems transformation through agroecology. This means supporting leaders and organizations with expertise across the four pathways for change:

1. Expand the evidence base and reframe narratives;
2. Align policy, regulation, and finance;
3. Rebalance power and foster accountability; and
4. Create enabling conditions for agrochemical transitions.

Taken together, these action pathways are not incremental fixes. They are complementary, mutually reinforcing strategies that require coordinated action across all stakeholders. Phasing out harmful agrochemicals and building just, resilient, and equitable food systems are not sequential steps but part of the same transition. Delivered at the pace and scale this moment demands, that transition can break decades of agrochemical dependency; restore the health of soils, farmers, workers, and consumers alike; and put food systems on a path toward regeneration rather than depletion.

As the contributors to this compendium demonstrate with growing evidence and practical experience, momentum toward agrochemical-free food systems is building—but it will not sustain itself. Philanthropy has a decisive role to play by engaging meaningfully with affected communities, civil society, researchers, and policymakers; deepening collaboration across agrochemical issue areas; and strengthening the organizations working to accelerate agroecological transitions. These investments extend beyond individual projects—they strengthen the people, organizations, networks, and collaborative infrastructure needed to sustain systems change.

The evidence, policy models, and movements already exist. The opportunity now is to match that momentum with sustained investment and coordinated action.



Photo credit: Arun Mohan, Media Collective, India

Glossary

Agrochemicals
Chemicals used in agriculture. In this report, we focus on synthetic nitrogen fertilizers and synthetic pesticides.

Agroecology
A holistic approach to farming that applies ecological principles to agricultural systems, aiming to produce food sustainably while protecting the environment, supporting biodiversity, and ensuring social equity.

Ammonia
A chemical compound consisting of nitrogen and hydrogen. It is a colourless gas with a distinct odour and is corrosive and acutely toxic. Ammonia is produced both naturally from bacterial processes and synthetically. It is used in many industrial applications, including in the production of synthetic nitrogen fertilizers.

Biofuel
A fuel source derived from organic matter (biomass), such as plants, algae, or animal waste.

Feedstock
Raw materials used for manufacturing plastics or other chemical products or fuels.

Fertilizer
A substance (either organic or synthetic) that is added to soil or plants to increase their productivity. Synthetic fertilizers are derived from mineral or fossil fuel extraction. The three primary nutrients needed for plant growth—nitrogen (N), phosphorus (P), and potassium (K)—form the basis of industrial agricultural fertilizers.

Food security
When all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food sovereignty
The right of countries and peoples to set their own agricultural and food policies.

Fossil fertilizers
Synthetic fertilizers derived from fossil fuels.

Fossil gas
A type of fossil fuel commonly known as "natural gas" that consists primarily of the hydrocarbon methane.

Highly hazardous pesticides (HHPs)
Pesticides acknowledged to present particularly high levels of acute or chronic hazards to health or environment. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be considered to be, and treated as, highly hazardous.

Industrial agriculture
A large-scale, intensive method of food production dominated by large corporations that is geared toward high yields and involves the use of chemical fertilizers and pesticides.

Just transition
A shift to a sustainable, low-carbon, and climate-resilient economy that is fair, inclusive, and leaves no one behind.

Methane (CH_4)
A potent greenhouse gas and hydrocarbon compound consisting of one carbon atom and four hydrogen atoms. It is a colourless, odourless, and flammable gas. It is the main material constituent of the fossil fuel known as "natural gas."

Microplastics
Tiny plastic pieces smaller than 5 millimetres consisting of synthetic polymers. Microplastics can fragment into smaller particles called nanoplastics.

Monoculture
Monocultures are large areas of land cultivated with a single crop, using methods that imply a high level of inputs, such as agrochemicals and machinery.

Nitrous oxide
A colourless gas, also known as "laughing gas." It is used as an anesthetic, among other applications. It is also a potent greenhouse gas emitted from industrial processes, fuel combustion, and, most widely, from agricultural soils treated with nitrogen fertilizers.

Nutrient cycling
The transfer or cycling of nutrients between the physical environment and living organisms.

Organic farming
A movement and form of agriculture based on the principles of health, ecology, fairness, and care. Organic farming relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than inputs with adverse effects, and combines traditional knowledge, innovation, and science. "Organic" is also a protected term and consumer label in many countries, where its use requires adherence to public or private standards based on organic principles, including restrictions or prohibitions on synthetic pesticides and fertilizers.

Pesticides
Pesticides include any substance, or mixture of substances of chemical or biological ingredients, intended for repelling, destroying, or controlling any pest or regulating plant growth.

Petrochemicals
Fossil fuel–derived chemicals, some of which are used to produce plastics or agrochemicals.

PFAS
Per- and polyfluoroalkyl substances (PFAS) are defined as fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it); i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–) is a PFAS.

Planetary boundaries
Geophysical limits to the processes that regulate the stability and resilience of the Earth's systems. According to the Stockholm Resilience Centre, the current framework consists of nine biophysical processes, and the boundaries for each represent a scientifically based "safe" level of human interference. The boundaries collectively represent the limits of the "safe operating space for humanity."

Regenerative agriculture
No universally accepted definition of regenerative agriculture exists to date. Its use ranges from regenerative organic and deep agroecology to no-till and conservation agriculture with high use of agrochemicals.

Synthetic nitrogen fertilizer
Inorganic fertilizer derived from ammonia and used primarily in the form of urea or ammonium nitrate.

Urea
A nitrogenous compound made from ammonia and carbon dioxide, used for nitrogen fertilizers.

Endnotes

[1] FAO and WHO, International Code of Conduct on Pesticide Management: Guidelines on Highly Hazardous Pesticides, 2016.

[2] EPA, Herbicides. Accessed July 2026.

[3] Crop Protection Network, Fungicide Use in Field Crops Web Book, 2026.

[4] EPA, Insecticides. Accessed July 2026.

[5] EPA, Types of Pesticide Ingredients. Accessed July 2026.

[6] FAO, FAOSTAT, 2026.

[7] UNEP, Report of the International Conference on Chemicals Management on the Work of Its Fourth Session, 2015.

[8] FAO, Introduction to Highly Hazardous Pesticides (HHP). Accessed July 2026.

[9] Gore et al., Endocrine Disrupting Chemicals: Threats to Human Health, 2024.

[10] Endocrine Disruption Exchange, EDC Factsheet. Accessed July 2026.

[11] Environmental Health News, What Are Endocrine Disrupting Chemicals? Accessed July 2026.

[12] Donley et al., Forever Pesticides: A Growing Source of PFAS Contamination in the Environment, 2024.

[13] FAO, FAOSTAT: Fertilizers by Nutrient, 2025.

[14] Jiang et al., Urea Fertilization Significantly Promotes Nitrous Oxide Emissions from Agricultural Soils and Is Attributed to the Short-Term Suppression of Nitrite-Oxidizing Bacteria During Urea Hydrolysis, 2024; Soares et al., Nitrous Oxide Emission Related to Ammonia-Oxidizing Bacteria and Mitigation Options from N Fertilization in a Tropical Soil, 2016.

[15] Liu et al., Runoff and Nutrient Losses in Citrus Orchards on Sloping Land Subjected to Different Surface Mulching Practices in the Danjiangkou Reservoir Area of China, 2012.

[16] Breitenbeck et al., Effects of Anhydrous Ammonia Fertilization on Emission of Nitrous Oxide from Soils, 1980.

[17] Spencer et al., A Hazard and Operability Study of Anhydrous Ammonia Application in Agriculture, 1993.

[18] Erisman et al., How a Century of Ammonia Synthesis Changed the World, 2008.

[19] Belfer Center for Science and International Affairs, The Colors of Hydrogen, 2024.

[20] CIEL, Fossils, Fertilizers, and False Solutions: How Laundering Fossil Fuels in Agrochemicals Puts the Climate and the Planet at Risk, 2022.

[21] U.S. Department of Energy, Technical Targets for Proton Exchange Membrane Electrolysis. Accessed July 2026.

[22] IEA, Global Hydrogen Review 2026, 2026.

[23] Tonelli et al., Global Land and Water Limits to Electrolytic Hydrogen Production Using Wind and Solar Resources, 2023.

[24] WRI, The World Is Growing More Crops—But Not for Food, 2022.

[25] Global Alliance for the Future of Food, Power Shift: Why We Need to Wean Industrial Food Systems Off Fossil Fuels, 2023.

[26] International Energy Agency, Ammonia Technology Roadmap, 2021; CIEL, Fossils, Fertilizers, and False Solutions: How Laundering Fossil Fuels in Agrochemicals Puts the Climate and the Planet at Risk, 2022.

[27] Urgewald, The Global Coal Exit List 2025: Troubling Trends Towards Chemicals and Captive Power, 2025.

[28] Reuters, China's Coal-Based Urea Insulates Its Farmers from Global Fertiliser Turmoil, 2026.

[29] 观研报告网, 我国合成行业：产能由转增且以煤制为主 绿项目建设伐不断加快_观研报告网 (Chinabaogao.com). (Translation: Research Report Network, China's Synthetic Ammonia Industry: Production Capacity Shifts from Decline to Growth, with Coal-Based Production Dominating; Green Ammonia Project Development Accelerates.)

[30] Nature, Tracing Fossil-Based Plastics, Chemicals and Fertilizers Production in China, 2024.

[31] Urgewald, The Global Coal Exit List 2025: Troubling Trends Towards Chemicals and Captive Power, 2025.

[32] IPES-Food, Fuel to Fork: What Will It Take to Get Fossil Fuels Out of Our Food Systems?, 2025.

[33] FAO, FAOSTAT, 2026.

[34] FAO, The Future of Food and Agriculture: Alternative Pathways to 2050, 2018.

[35] FAO, Pesticides Use and Trade, 1990–2023, 2025.

[36] Organic Consumers Association, A Short History of Glyphosate, 2017.

[37] IARC, IARC Monographs Volume 112: Evaluation of Five Organophosphate Insecticides and Herbicides, 2015.

[38] FAO, FAOSTAT: Fertilizers by Nutrient, 2025.

[39] FAO, FAOSTAT: Pesticide Use. Accessed July 2026.

[40] FAO, Agricultural Production Statistics, 2024.

[41] IFA, Assessment of Fertilizer Use by Crop at the Global Level, 2018.

[42] FAO, Pesticides Use and Trade, 1990–2022, 2024.

[43] Clements et al., Global Agricultural Productivity Is Threatened by Increasing Pollinator Dependence Without a Parallel Increase in Crop Diversification, 2022.

[44] West et al., Half of Global Agricultural Calories Are Not Available for Human Consumption, 2026.

[45] CDC, Ultra-Processed Food Consumption in Youths and Adults in the United States, August 2021–August 2023, 2025.

[46] FAO, FAOSTAT, 2026.

[47] FAO, FAOSTAT, 2026.

[48] Mallin et al., Industrialized Animal Production: A Major Source of Nutrient and Microbial Pollution to Aquatic Ecosystems, 2003.

[49] Hristov et al., Mitigation of Greenhouse Gas Emissions in Livestock Production: A Review of Technical Options for Non-CO2 Emissions, 2013.

[50] Montes et al., Mitigation of Methane and Nitrous Oxide Emissions from Animal Operations: II. A Review of Manure Management Mitigation Options, 2013.

[51] United Nations, Food and Climate Change: Healthy Diets for a Healthier Planet. Accessed July 2026; IATP, Roasting the Planet: Big Meat and Dairy's Big Emissions, 2025.

[52] Poore et al., Reducing Food's Environmental Impacts Through Producers and Consumers, 2018.

[53] Cassidy et al., Redefining Agricultural Yields: From Tonnes to People Nourished per Hectare, 2013.

[54] Erenstein et al., Global Maize Production, Consumption and Trade: Trends and R&D Implications, 2022; Ritchie, Drivers of Deforestation, 2021.

[55] Cassidy et al., Redefining Agricultural Yields: From Tonnes to People Nourished per Hectare, 2013.

[56] Project Drawdown, Only Half of Calories Produced on Croplands Are Available for Human Consumption, Study Finds, 2026.

[57] Van Boeckel et al., Global Trends in Antimicrobial Resistance in Animals in Low- and Middle-Income Countries, 2019.

[58] Khoury et al., Increasing Homogeneity in Global Food Supplies and the Implications for Food Security, 2014.

[59] Leite et al., Ultra-Processed Foods Should Be Central to Global Food Systems Dialogue and Action on Biodiversity, 2022.

[60] Menichetti et al., Machine Learning Prediction of the Degree of Food Processing, 2023.

[61] Gramza-Michałowska, The Effects of Ultra-Processed Food Consumption: Is There Any Action Needed?, 2020.

[62] IFA, Assessment of Fertilizer Use by Crop at the Global Level, 2018.

[63] IFPRI, Food Versus Fuel v2.0: Biofuel Policies and the Current Food Crisis, 2023.

[64] Ritchie and Rosado, Putting Solar Panels on Land Used for Biofuels Would Produce Enough Electricity for All Cars and Trucks to Go Electric, 2026; Ritchie and Rosado, Could Biofuels Meet Demand for Global Aviation?, 2026.

[65] Cassidy et al., Redefining Agricultural Yields: From Tonnes to People Nourished per Hectare, 2013.

[66] Dinca et al., A Mixture of 13 Pesticides, Contaminants, and Food Additives Below Individual NOAELs Produces Histopathological and Organ Weight Changes in Rats, 2023.

[67] Mesnage et al., Regulatory Assessment of Pesticide Mixtures: A Challenge for the Protection of Human Health, 2022.

[68] UC Berkeley CERCH, CHAMACOS Studies. Accessed July 2026.

[69] Kepner, Synergy: The Big Unknowns of Pesticide Exposure, 2004.

[70] Planetary Health Check, New EAT-Lancet Report Emphasizes Challenges but Also Pathways Forward, 2025.

[71] Planetary Boundaries Science, Planetary Health Check 2025, 2025.

[72] Wang et al., Surface-Water Nitrate Exposure to World Populations Has Expanded and Intensified during 1970–2010, 2023.

[73] Grandjean and Landrigan, Neurobehavioural Effects of Developmental Toxicity, 2014.

[74] United Nations, Report of the Special Rapporteur on the Right to Food, 2017.

[75] FAO, The State of Food and Agriculture 2024: Value-Driven Transformation of Agrifood Systems, 2024.

[76] CIEL, Fossils, Fertilizers, and False Solutions, 2022 .

[77] UNEP, Rise in Nitrous Oxide Emissions Endangers Pathway to 1.5°C and Ozone Layer Recovery, 2024.

[78] UNEP, Global Nitrous Oxide Assessment, 2024.

[79] Sandström et al., Disparate History of Transgressing Planetary Boundaries for Nutrients, 2023.

[80] Lassaletta et al., 50 Year Trends in Nitrogen Use Efficiency of World Cropping Systems: The Relationship Between Yield and Nitrogen Input to Cropland, 2014.

[81] Tang et al., Risk of Pesticide Pollution at the Global Scale, 2021.

[82] PANNA, Pesticides and Climate Change: A Vicious Cycle, 2023.

[83] PANNA, Pesticides and Climate Change: A Vicious Cycle, 2023.

[84] Gunstone et al., Pesticides and Soil Invertebrates: A Hazard Assessment, 2021.

[85] PANNA, Pesticides and Soil Health: State of the Science and Viable Alternatives. Fact Sheet, 2020; Sim et al., Impact of Twenty Pesticides on Soil Carbon Microbial Functions and Community Composition, 2022; Tang et al, Risk of Pesticide Pollution at the Global Scale, 2019.

[86] Heap, The International Herbicide-Resistant Weed Database, 2026.

[87] Wan et al., Pesticides Have Negative Effects on Non-Target Organisms, 2025.

[88] Wan et al., Pesticides Have Negative Effects on Non-Target Organisms, 2025.

[89] FAO, Understanding Antimicrobial Resistance in Aquaculture, 2020.

[90] FAO, Why Bees Matter: The Importance of Bees and Other Pollinators for Food and Agriculture, 2018.

[91] Carrington, Plummeting Insect Numbers "Threaten Collapse Of Nature," 2019.

[92] Sánchez-Bayo and Wyckhuys, Worldwide Decline of the Entomofauna: A Review of Its Drivers, 2019.

[93] United Nations, Our Global Food System Is the Primary Driver of Biodiversity Loss, 2021.

[94] Xerces Society, Pesticides and Soil Invertebrates, 2011.

[95] BirdLife South Africa, Birds and Agrochemicals. Accessed May 2025.

[96] Zenodo, State of India's Birds 2023, 2023.

[97] SoIB, State of India's Birds, 2023: Range, Trends, and Conservation Status, 2023.

[98] Simmer et al., Climate Change and the Sea: A Major Disruption in Steady State and the Master Variables, 2023.

[99] The Convention on Wetlands, Global Wetland Outlook, 2025.

[100] Kanda et al., Effects of Herbicide on Various Life Forms with Special Reference to the Paddy Fields in the Eastern Belts of India, 2023.

[101] McMahon et al., Fungicide-Induced Declines of Freshwater Biodiversity Modify Ecosystem Functions and Services, 2012.

[102] Systemiq, Invisible Ingredients, 2025.

[103] National Library of Medicine, A Scientific Review of Pesticides: Classification, Toxicity, Health Effects, Sustainability, and Environmental Impact, 2024.

[104] Megistie et al., Environmental and Human Health Impacts of Agricultural Pesticides on BIPOC Communities in the United States: A Review from an Environmental Justice Perspective, 2025.

[105] Roberts et al., Pesticide Exposure in Children, 2012.

[106] Olirk et al., Occupational Pesticide Exposure Risks and Gendered Experiences Among Women in Horticultural Farms in Northern Tanzania, 2025.

[107] Faraj, Community Health Impacts of Pesticide Exposure: Pathways, Vulnerable Populations, and Public Health Responses, 2026.

[108] Rillig et al., Microplastic Effects on Terrestrial Plants and Soil Biota, 2025.

[109] Wang et al., Surface-Water Nitrate Exposure to World Populations Has Expanded and Intensified during 1970–2010 https://pmc.ncbi.nlm.nih.gov/articles/PMC10702521, 2023.

[110] Crippa et al., Air Pollutant Emissions from Global Food Systems Are Responsible for Environmental Impacts, Crop Losses and Mortality, 2022.

[111] Lopes-Ferreira et al., Consumption of Fruits and Vegetables Contaminated with Pesticide Residues in Brazil: A Systematic Review with Health Risk Assessment, 2023.

[112] Tang et al., Transboundary Impacts of Pesticide Use in Food Production, 2025.

[113] Shekhar, C. A Systematic Review of Pesticide Exposure, Associated Risks, and Long-Term Human Health Impacts, 2024.

[114] WHO, Chemical Safety: Pesticides, 2020.

[115] Duursen et al., Safeguarding Female Reproductive Health Against Endocrine Disrupting Chemicals: The FREIA Project, 2020.

[116] Ellis et al., Adult Organophosphate and Carbamate Insecticide Exposure and Sperm Concentration: A Systematic Review and Meta-Analysis of the Epidemiological Evidence, 2023.

[117] Chiu et al., Association Between Pesticide Residue Intake From Consumption of Fruits and Vegetables and Pregnancy Outcomes Among Women Undergoing Infertility Treatment With Assisted Reproductive Technology, 2018.

[118] Roberts et al., Pesticide Exposure in Children, 2012.

[119] Marquez et al., Kids on the Frontline: How Pesticides Are Undermining the Health of Rural Children, 2016.

[120] Dunn et al., Endocrine Disrupting Chemicals in Human Milk: A Systematic Review of Concentrations and Potential Health Implications, 2025.

[121] Environmental Working Group, Body Burden: The Pollution in Newborns, 2005.

[122] Beck, et al., Environmental Induced Transgenerational Inheritance Impacts Systems Epigenetics in Disease Etiology, 2022.

[123] Marquez et al., Kids on the Frontline: How Pesticides Are Undermining the Health of Rural Children, 2016; Roberts et al., Pesticide Exposure in Children, 2012.

[124] López-Gálvez et al., Prenatal Pesticide Exposure and Child Neurodevelopment, 2024; Patel et al., Parental Occupational Exposure to Pesticides, Animals, and Organic Dust and Risk of Childhood Leukemia and Central Nervous System Tumors: Findings From the International Childhood Cancer Cohort Consortium (I4C), 2019.

[125] Ward et al., Workgroup Report: Drinking Water Nitrate and Human Health—An Updated Review, 2018.

[126] Pires et al., Chemical Mixtures and Children's Health: A Review of Current Evidence and Research Needs, 2024.

[127] Andersen et al., Pesticide Exposure and Neurodevelopmental Outcomes in Children, 2025.

[128] Li et al., Early-Life Pesticide Exposure and Child Health, 2026.

[129] Zhang et al., Exposure to Glyphosate-Based Herbicides and Risk for Non-Hodgkin Lymphoma: A Meta-Analysis and Supporting Evidence, 2019.

[130] Orantes et al., Chronic Interstitial Nephritis in Agricultural Communities (CINAC), 2023.

[131] OHCHR, Mandate of the Special Rapporteur on Toxics and Human Rights, 2021.

[132] Wyer et al., Ammonia Emissions from Agriculture and Their Contribution to Fine Particulate Matter: A Review of Implications for Human Health, 2022.

[133] Crippa et al., Air Pollutant Emissions from Global Food Systems Are Responsible for Environmental Impacts, Crop Losses and Mortality, 2022.

[134] Gunnarsson et al., Occupational Exposures and Neurodegenerative Diseases: A Systematic Literature Review and Meta-Analyses, 2019.

[135] Rohr et al., Pesticides and Global Health: A Call for Action, 2025.

[136] Mostafalou and Abdollahi, Pesticides: An Update of Human Exposure and Toxicity, 2017.

[137] London et al., Neurobehavioral and Neurodevelopmental Effects of Pesticide Exposures, 2012.

[138] WHO, Preventing Suicide by Phasing Out Highly Hazardous Pesticides, 2024.

[139] Bonvoisin et al., Bhopal Gas Tragedy: An Analysis of Its Causes and Consequences, 2025.

[140] Mishra et al., Bhopal Gas Tragedy: Review of Clinical and Experimental Findings After 25 Years, 2009.

[141] PANNA, Bayer Found Responsible for Poisoning Children in Peru, 2002; Guardian, India School Lunch Poisoning: Children Die After Eating Pesticide-Tainted Food, 2013.

[142] Calvert et al., Acute Pesticide Poisoning Among Agricultural Workers in the United States, 1998–2005, 2008.

[143] Shekhar, C. A Systematic Review of Pesticide Exposure, Associated Risks, and Long-Term Human Health Impacts, 2004.

[144] Terre Solidaire et al., Pesticides: A Model That Is Costing Us Dearly. An Initial Cost-Benefit Analysis of the Pesticide Sector at the European Level, 2021.

[145] FAO, Global Report on Food Crises, 2023.

[146] FAO, General and Food Consumer Price Indices Inflation Rates, 2023.

[147] FAO, IFAD, UNICEF, WFP, and WHO, The State of Food Security and Nutrition in the World 2023, Urbanization, Agrifood Systems Transformation and Healthy Diets Across the Rural–Urban Continuum, 2023.

[148] FAO, WFP, and GNAFC, 2026 Global Report on Food Crises— Joint Analysis for Better Decisions, 2026.

[149] Clapp, Concentration and Crises: Exploring the Deep Roots of Vulnerability in the Global Industrial Food System, 2022.

[150] FAO, Credit to Agriculture: Global and Regional Trends 2015–2024, 2026.

[151] IPES-Food, Land Squeeze: What Is Driving Unprecedented Pressures on Global Farmland and What Can Be Done to Achieve Equitable Access to Land?, 2024.

[152] De Schutter, The Right to Food, UN General Assembly, A/66/262, 2011.

[153] IPES-Food, Head in the Cloud, 2026.

[154] Lowder et al., Farms, Family Farms, Farmland Distribution and Farm Labour: What Do We Know Today?, 2019.

[155] IPES-Food, Land Squeeze: Soaring Land Prices, Grabs and Carbon Schemes Threaten Food Production, Experts Warn, 2024.

[156] PANAP, Building Community Resistance Against Land Grabbing, 2013.

[157] Mehrabi, Likely Decline in the Number of Farms Globally by the Middle of the Century, 2023.

[158] Canadian Biotechnology Action Network, Are GM Crops Better For Farmers?, 2015.

[159] African Centre for Biodiversity, The Changing Nature of Kenya's Seed Industry Sectors, 2022; Malesi, Battle Against Kenyan Law Banning Exchange of Indigenous Seeds Among Farmers Gains Momentum, 2024.

[160] FAO, The State of the World's Biodiversity for Food and Agriculture, 2019.

[161] Vandeman, Management in a Bottle: Pesticides and the Deskilling of Agriculture, 1995.

[162] UN Permanent Forum on Indigenous Issues, Indigenous Determinants of Health in the 2030 Agenda (E/C.19/2023/5), 2023.

[163] Montúfar, Perceptions of Agrodiversity and Seed-Saving Practices in the Northern Andes of Ecuador, 2019.

[164] Gaberell, Sharp Rise in EU Export Trade in Banned Pesticides Despite European Commission Promises, 2025.

[165] Bombardi, Brazil: More Cultivation, More Pesticides, More Exports, 2022.

[166] De Groot et al., Global Inequities in Pesticide Legislation: Nearly Half of Pesticides Approved in Major Crops in Latin America Are Not Allowed in the European Union, 2026.

[167] ETC Group and GRAIN et al., Top 10 Agribusiness Giants: Corporate Concentration in Food and Farming, 2026.

[168] ETC Group and GRAIN et al., Top 10 Agribusiness Giants: Corporate Concentration in Food and Farming in 2025, 2025.

[169] Organization for Competitive Markets, The Debilitating Effects of Concentration In Markets Affecting Agriculture, 2009.

[170] Buthelezi et al., Empowering African Food Producers and Agricultural Enterprises Through Stronger Competition Law and Policy, 2023; Mahuma et al., The State of Competition in Tanzania's Fertilizer Markets, 2024.

[171] DeSmog, Fertiliser and Grain Bosses Bank $66 Million Selling Shares After Iran War, 2026.

[172] GRAIN and IATP, A Corporate Cartel Fertilizes Food Inflation, 2023.

[173] U.S. Right to Know, Merchants of Poison: How Monsanto Sold the World on a Toxic Pesticide, 2022.

[174] Chachere, Conflicts of Interest Affect Conservation Science, 2010.

[175] Rohr, The Atrazine Saga and Its Importance to the Future of Toxicology, Science, and Environmental and Human Health, 2021; Aviv, A Valuable Reputation, 2014; Howard, Special Report: Syngenta's Campaign to Protect Atrazine, Discredit Critics, 2013.

[176] Gillam, Outrage at European Science Center as Director Ousted After Study on Glyphosate, 2026.

[177] GMWatch, Ramazzini Institute Researchers Protest: Our Independence Is at Risk, 2026.

[178] Lighthouse Reports, Poison PR, 2024.

[179] Gillam, et al., "Defend or Be Damned": How a U.S. Company Uses Government Funds to Suppress Pesticide Opposition Around the World, 2024.

[180] Bayer, Political Advocacy Transparency Report, 2024.

[181] Gillam, Thailand's Reversal on Glyphosate Ban Came After Bayer Scripted U.S. Intervention, Documents Show, 2020.

[182] Gillam, Revealed: Monsanto Owner and U.S. Officials Pressured Mexico to Drop Glyphosate Ban, 2021.

[183] U.S. Right to Know, Bayer Lobby Tracker, 2026.

[184] PAN International, Statement of Civil Society and Indigenous Peoples on the End of the FAO Partnership with CropLife International, 2024.

[185] Corporate Accountability & FIAN International, Corporate Capture of FAO: Industry's Deepening Influence on Global Food Governance, 2022.

[186] WHO, List of Entities in Official Relations with WHO, 2026.

[187] FAO, FAO and the International Fertilizer Association Renew Decade-Long Commitment to Sustainable Agrifood Systems, 2023.

[188] Modern Ag Alliance, About the Modern Ag Alliance. Accessed July 2026.

[189] Howell and Pearson, Ag Front Group Shields Bayer in Controversial Roundup Liability Fights, 2026.

[190] U.S. Right to Know, Modern Ag Alliance Is a Bayer Lobbying and PR Group, 2026.

[191] PAN, Bayer Banks on Congress for Permanent Roundup Immunity, 2026.

[192] Guardian, Trump Order Protects Weedkiller from Cancer Warning Labels, 2026.

[193] Guardian, Monsanto Asks Supreme Court to Shield It from Pesticide Lawsuits, 2026.

[194] Intercept, EPA's Pesticide Office Is Captured by Industry, 2021.

[195] PANNA, EPA's Revolving Door, 2023.

[196] Bloomberg, Bayer Said to Secure $63 Billion in Financing for Monsanto Bid, 2016.

[197] Foodrise, Bankrolling the Butchers, 2021.

[198] IDRC, Markets and Rural Poverty: Upgrading in Value Chains, 2011.

[199] Bijman, Contract Farming in Developing Countries: An Overview, 2008.

[200] Springer Nature, Contract Farming in Perspective, 2025.

[201] IPES-Food, Land Squeeze, 2024.

[202] GRAIN, Pension Funds: Key Players in the Global Farmland Grab, 2011.

[203] Fairbairn, "Like Gold with Yield": Evolving Intersections Between Farmland and Finance, 2014.

[204] Regmi et al., Effects of Crop Insurance on Farm Input Use: Evidence From Kansas Farm Data, 2022.

[205] Möhring et al., Crop Insurance and Pesticide Use in European Agriculture, 2020.

[206] Zhang et al., Agricultural Insurance, Premium Subsidies and Chemical Inputs: Evidence From China, 2026.

[207]Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025.

[208] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025.

[209] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025.

[210] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025.

[211] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025.

[212] Bosso, Pesticides and Politics: The Life Cycle of a Public Issue, 1988.

[213] Patel, The Long Green Revolution, 2012.

[214] Stone, The Agricultural Dilemma: How Not to Feed the World, 2022; Cowan et al., Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies, 1996.

[215] Kloppenburg, First the Seed: The Political Economy of Plant Biotechnology, 2004.

[216] Vanloqueren et al., How Agricultural Research Systems Shape a Technological Regime, 2009.

[217] Benbrook et al., Trends in Glyphosate Herbicide Use in the United States and Globally, 2016.

[218] Duke et al., The Search for New Herbicide Mechanisms of Action, 2022.

[219] PANNA, The Pesticide Takeover, 2025.

[220] ETC Group and GRAIN, Top 10 Agribusiness Giants: Corporate Concentration in Food & Farming in 2025, 2025.

[221] IPES-Food, From Uniformity to Diversity, 2016.

[222] Bronson, The Immaculate Conception of Data: Agribusiness, Activism, and the Politics of Knowing, 2022.

[223] Lajoie-O'Malley et al., The Futures of Digital Agriculture, 2020.

[224] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025; IPES-Food, From Uniformity to Diversity, 2016.

[225] Pahalvi et al., Chemical Fertilizers and Their Impact on Soil Health. Microbiota and Biofertilizers, 2021; IPES-Food, From Uniformity to Diversity, 2016.

[226] Bakker et al., Neonicotinoids in Global Agriculture: Evidence for a New Pesticide Treadmill?, 2020; IATP, Revisiting Crisis by Design: The Agricultural Technology Treadmill, 2020.

[227] Bayer, GMO Transparency Report, 2023.

[228] Benbrook, Trends in Glyphosate Herbicide Use in the United States and Globally, 2016.

[229] Brookes et al., Glyphosate Use in Agricultural Production: It's Contribution to Global Carbon Dioxide Emissions, 2026.

[230] PANNA, The Pesticide Takeover, 2025.

[231] Heap, The International Herbicide-Resistant Weed Database, 2026.

[232] Ohio State University, Changes in Dicamba and 2,4-D Use and Drift Issues. Accessed July 2026.

[233] CBAN, Herbicide Tolerant Crops, 2024.

[234] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters, 2025; Center for Food Safety, Monsanto vs. U.S. Farmers, 2019.

[235] De Schutter, Interim Report of the Special Rapporteur on the Right to Food, 2011.

[236] AFSA, Corporate Capture of Agricultural Research and Extension, 2020.

[237] AFSA, False Promises: The Alliance for a Green Revolution in Africa (AGRA), 2020.

[238] Mottaleb et al., Small Businesses, Potentially Large Impacts: The Role of Fertilizer Traders as Agricultural Extension Agents in Bangladesh, 2019.

[239] Damalas et al., Pesticide Misuse Among Small Andean Farmers Stems from Pervasive Misinformation by Retailers, 2022.

[240] Embrapa, Herbicide Use in Brazil Grew 128% Between 2010 and 2020, 2025.

[241] FAO, Pesticides Use and Trade, 1990–2021, 2023.

[242] Bombardi, A Geography of Agrotoxins Use in Brazil and Its Relations to the European Union, 2019.

[243] GFRAS, Brazil, 2013.

[244] GRAIN, Corporate Bioinputs: Agribusiness's New Toxic Trap, 2024.

[245] MarketsandMarkets, Agricultural Biologicals Market, 2025.

[246] GRAIN, Corporate Bioinputs: Agribusiness's New Toxic Trap, 2024; Juleen and Reeves, The Corporate Capture of Biopesticides, 2026.

[247] Heinrich Böll Foundation, Soil Atlas: Green Fertilisers, 2024.

[248] Tonelli et al., Global Land and Water Limits to Electrolytic Hydrogen Production Using Wind and Solar Resources, 2023.

[249] Yara, Yara Climate Choice Fertilizers. Accessed July 2026.

[250] DeSmog, Green Goals, Dirty Fuel: Europe's Fertiliser Industry and Shale Gas, 2025; Yara, Carbon Capture and Storage. Accessed July 2026.

[251] Yara, PepsiCo Europe and Yara Partner to Decarbonize Crop Production, 2024.

[252] Energi Media, U.S. Natural Gas Production Hits Record in 2025, EIA Says, 2026.

[253] CIEL, Emissions Unleashed: The Climate Crisis and America's Petrochemical Boom, 2024.

[254] Blois, Technology Is Helping Farmers Grow More Food with Less Chemicals, 2023.

[255] ETC Group, From Commons to Code: How Digital Platforms Rewire Agriculture and Reshape Power, 2022.

[256] Bronson, The Immaculate Conception of Data: Agribusiness, Activism, and the Politics of Knowing, 2022.

[257] Bronson, The Immaculate Conception of Data: Agribusiness, Activism, and the Politics of Knowing, 2022.

[258] IPES-Food, From Uniformity to Diversity, 2016.

[259] IPES-Food, From Uniformity to Diversity, 2016; IPES-Food, Food from Somewhere, 2024.

[260] Clapp and Isakson, Risky Returns: The Implications of Financialization in the Food System, 2018.

[261] Tang et al., Index Investment and the Financialization of Commodities, 2012; Moret-Bailly et al., The Costs and Benefits of Transitioning to Sustainable Agriculture in the EU, 2024.

[262] FAO, A Multi-Billion-Dollar Opportunity: Repurposing Agricultural Support to Transform Food Systems, 2021.

[263] FAO, A Multi-Billion-Dollar Opportunity: Repurposing Agricultural Support to Transform Food Systems, 2021.

[264] Jayne et al., Review: Taking Stock of Africa's Second-Generation Agricultural Input Subsidy Programs, 2018.

[265] Spielman et al, Fertilizer Policy Reforms in the Midst of Crisis: Evidence from Rwanda, 2025.

[266] Jayne et al., Input Subsidy Programs in Sub-Saharan Africa: A Synthesis of Recent Evidence, 2013.

[267] Black et al., Fossil Fuel Subsidies Surged to Record $7 Trillion, 2023.

[268] Tostado, Anonymous Ammonia, 2023.

[269] Alexander, Louisiana Bets Big on "Blue Ammonia": Communities Along Cancer Alley Brace for the Cost, 2026.

[270] WHO, The Public Health Impact of Chemicals: Knowns and Unknowns, 2016.

[271] FAO, The State of Food and Agriculture 2024, 2024.

[272] Systemiq, Invisible Ingredients, 2025.

[273] International Finance Corporation, , 2024.

[274] Center for Global Development, , 2025.

[275] Pan African Visions, The World Bank Group Aims to Help Transform African Agriculture, 2026.

[276] Daniel, Zambia: Structural Adjustment or Downward Spiral?, 1985.

[277] World Bank, Enabling the Business of Agriculture 2019, 2019.

[278] Makinde, Behind Accumulation and Dispossession: State and Large-Scale Agricultural Land Investments in Nigeria, 2021.

[279] Teschemacher et al., Zambia Agriculture Policy Framing, 2023.

[280] Clapp, Titans of Industrial Agriculture: How a Few Giant Corporations Came to Dominate the Farm Sector and Why It Matters,, 2025.

[281] Devex, AGRA Has Failed to Improve Africa's Food Security, Report Finds, 2022.

[282] AGRA, AGRA's Five-Year Strategy: Sustainably Growing Africa's Food Systems, 2023.

[283] Wise, AGRA: Still Failing Africa's Farmers, 2022.

[284] World Bank, , 2026.

[285] ETC Group and GRAIN, Top 10 Agribusiness Giants in 2025, 2025.

[286] USDA Foreign Agricultural Service, Impacts and Repercussions of Price Increases on the Global Fertilizer Market, 2025.

[287] PAN Europe, Double Standards, Double Risk: Banned Pesticides in Europe's Food Supply, 2022.

[288] Weir and Schapiro, Circle of Poison: Pesticides and People in a Hungry World, 1981.

[289] European Parliament, Opinion of the Committee on Development, 2023.

[290] Heinrich Böll Foundation, Pesticide Atlas: Brazil. 2022.

[291] FAO, FAOSTAT: Pesticides Trade, 2026.

[292] Coalition to Stop Export of EU Banned Pesticides, 326 NGOs and Trade Unions Demand the End of the EU's Export of Banned Pesticides and Other Hazardous Chemicals, 2022.

[293] PAN Germany, Study: Export of Highly Hazardous Pesticide Active Ingredients from Germany, 2022.

[294] PANNA, Thailand Upholds Triple Pesticide Ban, Despite U.S. Pushback, 2019.

[295] EFE, Trump Pidió Más Dinero Para Colombia Si Retoma Fumigaciones Con Glifosato, 2019.

[296] FAO, The State of Food and Agriculture 2024, 2024.

[297] De Schutter, The Political Economy of Food Systems Reform, 2017; IPES-Food, From Uniformity to Diversity, 2016.

[298] Sweitzer et al., Food Accounted for 12.9 Percent of U.S. Households' Expenditures in 2023, 2024.

[299] Furlong, Europeans Want Cheap, Pesticide-Free Food; Industry Campaign Says It Can't Be Done, 2016.

[300] Seidel et al., The True Price of External Health Effects from Food Consumption, 2023.

[301] INRAE, Pesticide-Free Agriculture as a New Paradigm for Research, 2022.

[302] HLPE, Critical, Emerging and Enduring Issues for Food Security and Nutrition, 2022; FAO, The State of Food Insecurity in the World, 2001.

[303] Bayer, Feeding a Growing World Population. Accessed June 2025.

[304] Holt-Gimenez, We Already Grow Enough Food for 10 Billion—and Still Can't End Hunger, 2012.

[305] United Nations, Food. Accessed July 2026.

[306] IFAD, The People Feeding the World Should Get Their Due, 2023.

[307] Lindsey Sloat et al., The World Is Growing More Crops—But Not for Food, 2022.

[308] West et al., Half of Global Agricultural Calories Are Not Available for Human Consumption, 2026.

[309] Heinrich Böll Stiftung et al., Meat Atlas: Facts and Figures About the Animals We Eat, 2021; HLPE, Critical, Emerging and Enduring Issues for Food Security and Nutrition, 2022.

[310] MacDonald et al., Rethinking Agricultural Trade Relationships in an Era of Globalization, 2015.

[311] DeSmog, A Guide to Six Greenwashing Terms Big Ag Is Bringing to COP28, 2023.

[312] Starman et al., Rethinking No-Till: Toxic Impacts of Conventional No-Till on Soil, Biodiversity, and Human Health, 2025.

[313] IPCC, AR6 Synthesis Report: Climate Change 2023, 2023.

[314] Yang et al., Climate Change Exacerbates the Environmental Impacts of Agriculture, 2024.

[315] EPA, Reregistration Eligibility Decision for Atrazine, 2006.

[316] Lane et al., Ultra-Processed Food Exposure and Adverse Health Outcomes, 2024; WHO, Diet, Nutrition and the Prevention of Chronic Diseases, 2022.

[317] Mahuma et al., The State of Competition in Tanzania's Fertilizer Markets, 2024.

[318] UNEP, Global Framework on Chemicals—For a Planet Free of Harm from Chemicals and Waste, 2023.

[319] Convention on Biological Diversity, Target 7: Reduce Pollution to Levels That Are Not Harmful to Biodiversity. Accessed July 2026.

[320] TCA Accelerator. Accessed July 2026.

[321] Convention on Biological Diversity, Kunming-Montreal Global Biodiversity Framework, 2022.

[322] UNEP, Global Framework on Chemicals – For a Planet Free of Harm from Chemicals and Waste, 2023.

[323] COP28 Presidency, COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action, 2023.

[324] Climate Action Network, CAN Guidance on Just Transition, 2023.

[325] Ladha et al., Biological Nitrogen Fixation and Prospects for Ecological Intensification in Cereal-based Cropping Systems, 2022.

[326] Kapeleka et al., Assessment of Unintentional Acute Pesticide Poisoning (UAPP) Amongst Cotton Farmers in Tanzania, 2025; Robinson et al., Assessment of Unintentional Acute Pesticide Poisoning Among Smallholder Vegetable Farmers in Trinidad and Jamaica, 2024.

[327] Stevenson et al., Extracts from Field Margin Weeds Provide Economically Viable and Environmentally Benign Pest Control Compared to Synthetic Pesticides, 2015.

[328] WHO, Resolution WHA76.17: The Impact of Chemicals, Waste and Pollution on Human Health, 2023.

[329] Salud con Lupa, Pesticidas en los Alimentos de 4 Ciudades. Accessed July 2026.

[330] Health and Environment Alliance, A Pesticide-Free EU. Accessed July 2026.

[331] Lighthouse Reports, Poison PR, 2024; Friends of the Earth, Merchants of Poison, 2022; *The New Yorker*, A Valuable Reputation, 2014.

[332] Corporate Europe Observatory, A Loud Lobby for a Silent Spring: The Pesticide Industry's Toxic Lobbying Tactics Against Farm to Fork, 2022.

[333] Friends of the Earth, Rethinking No-Till, 2025; Anderson, Clever Name, Losing Game? How Climate Smart Agriculture Is Sowing Confusion in the Food Movement, 2014; IFOAM – Organics International, Elevating Truly Regenerative Agriculture, 2025; IPES-Food, Smoke & Mirrors, 2022; Sherrington and Healy, Look Out for These 8 Big Ag Greenwashing Terms at COP30, 2025.

[334] CIEL, Fossils, Fertilizers, and False Solutions, 2022.

[335] Friends of the Earth, Regenerative Food Labels: What's Behind the Claim?, 2026.

[336] Regen10, Outcomes Framework. Accessed July 2026.

[337] Clapp et al., Viewpoint: The Case for a Six-Dimensional Food Security Framework, 2022.

[338] Bezner Kerr, Can Agroecology Improve Food Security and Nutrition? A Review, 2021.

[339] Blake, Agroecology Has a PR Problem. Here's How We Can Solve It, 2026; ETC Group, Small-Scale Farmers and Peasants Still Feed the World, 2022; Wijeratna, Agroecology: Scaling-up, Scaling-out, 2018.

[340] PAN UK and PAN International, Leveraging NBSAPs Beyond the CBD: How Action on Agroecology and Pesticides Delivers Across Multiple UN Policy Frameworks, 2024.

[341] PAN UK, Call to Phase Out Highly Hazardous Pesticides, 2023.

[342] PAN UK, Call to Phase Out Highly Hazardous Pesticides, 2023.

[343] Health and Environment Alliance, Chlorpyrifos-Methyl: Unpacking the History Behind the EU Ban and Court Case, 2023.

[344] Syngenta, Syngenta to Cease Paraquat Production in the UK in 2026, 2026.

[345] Centre for Suicide Prevention, From Dialogue to Action: How an Indian State Banned a Deadly Pesticide, 2026.

[346] Gillam, Vermont Becomes First US State to Ban Paraquat Herbicide Over Parkinson's Fears, 2026.

[347] EFFAT, The Time for Delay Is Over: EU Must Phase Out Pesticides and Build Sustainable Food Systems, 2025.

[348] Manzanaro, Brazil Faces EU Meat Export Ban Over Antibiotics Rules, 2026.

[349] CBD, Marine and Coastal Biodiversity: Precautionary Approach, 2006.

[350] Friends of the Earth Europe, Joint Statement for an Ambitious Pesticides Law That Protects People & Nature, 2023.

[351] UN, UNEP Working Group on Nitrogen. Accessed July 2026.

[352] UNEP, National Focal Points. Accessed July 2026.

[353] Sustainable Nitrogen Alliance, Building Resilience in UK Food Production: How Can the UK Break Our Dependence On Synthetic Nitrogen Fertiliser?, 2026.

[354] PAN UK, Conserving Biodiversity. Accessed July 2026.

[355] Committee on World Food Security, Agroecological and Other Innovative Approaches for Sustainable Agriculture and Food Systems That Enhance Food Security and Nutrition, 2021.

[356] COP28 Presidency, COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action, 2023.

[357] UNEP, UN Report Calls for Repurposing of USD 470 Billion of Agricultural Support That Distorts Prices, Environment and Social Goals, 2021.

[358] Gerasimchuk et al., Reforming Environmentally Harmful Subsidies: A Playbook, 2025.

[359] Sustainable Markets Initiative, Agribusiness Task Force. Accessed July 2026.

[360] Agroecology Coalition, Press Release: Governments Adopt Agroecology to Build Resilience to Conflict and Climate Shocks, 2026.

[361] Conservation International, Global Environment Facility Approves $1.7M for Nature-Positive Subsidy Reform, 2026; IISD, From Subsidies to Sustainability, 2026.

[362] FAO, UNDP, and UNEP, A Multi-Billion-Dollar Opportunity: Repurposing Agricultural Support to Transform Food Systems, 2021.

[363] PAN Europe, A Roadmap for a Pesticide Phase-Out, 2025; Foodrise, Exhausted Earth: How Fertiliser Corporations Destroyed the Nitrogen Cycle and How to Fix It, 2025.

[364] Nielsen et al., Ex-Post Evaluation of the Danish Pesticide Tax: A Novel and Effective Tax Design, 2023.

[365] Clapp and Howard, The Hunger Profiteers, 2023; EFFAT, EFFAT Reaction to Sustainable Use of Pesticide Regulation, 2022; BMAS, Aktualisierte wissenschaftliche Empfehlung zur Berufskrankheit "Parkinson-Syndrom durch Pestizide," 2025. (Translation: Updated Scientific Recommendation on the Occupational Disease "Parkinson Syndrome by Pesticides.")

[366] Mousseau, 38 Billion Dollar Question: Who Is Driving the Destructive Industrial Agriculture Model?, 2022.

[367] Harvard Law School Forum on Corporate Governance, The Prescience of ESG Investors: A Monsanto Case Study, 2018; Krimsky, The Monsanto Papers: Poisoning the Scientific Well, 2018.

[368] CIEL, Toxic Finance: The Banks and Investors Funding the Expansion of Petrochemicals in the US, 2026.

[369] NYC Comptroller's Office, NYC Comptroller Lander Proposes Excluding Future Private Markets Investments in Midstream and Downstream Fossil Fuel Infrastructure, 2024.

[370] Adasina, Issue Brief: Extractive Agriculture, 2024.

[371] ETC Group and GRAIN, Top 10 Agribusiness Giants: Corporate Concentration in Food and Farming in 2025, 2025; IPES-Food, Too Big to Feed, 2017.

[372] Advisory Centre for Competition Law & Policy in Africa. Accessed July 2026.

[373] Consortium of the Center to End Corporate Harm, Corporate Vectors of Chronic Disease—Using Internal Industry Documents to Craft Counterstrategies, 2026.

[374] PAN UK, Why The Pesticide Industry's Influence on Science and Policy Deserves More Attention, 2025; AFSA, Challenging the Green Revolution, 2025.

[375] UNICEF, Engaging With the Food and Beverage Industry: UNICEF Programme Guidance, 2023.

[376] Corporate Accountability and FIAN, Corporate Capture of FAO: Industry's Deepening Influence on Global Food Governance, 2022.

[377] IPES-Food, Who's Tipping the Scales? The Growing Influence of Corporations on the Governance of Food Systems, and How to Counter It, 2023; Foodrise, Fertilisers, 2026.

[378] Reuters, Bayer Hit With $2 Billion Roundup Verdict in US State of Georgia Cancer Case, 2025; Calatayud, Bayer Net Loss Widens on Weedkiller Litigation Charges, 2026; U.S. Right to Know, Monsanto Papers. Accessed July 2026.

[379] Guardian, Bayer Agrees to $10.9bn Settlement Over Monsanto's Weedkiller Roundup, 2020; Associated Press, Bayer Agrees to Pay $7.25bn to Settle Roundup Weedkiller Cancer Lawsuits, 2026.

[380] Gillam, Bayer Proposes $7.25 Billion Class Action Settlement in Roundup Litigation, 2026.

[381] Gillam, Judge Pressures Parkinson's Patients Over Syngenta Paraquat Settlement, 2026.

[382] ClientEarth, We've Forced Italian Authorities to Protect Citizens and Iconic Lake From Intensive Farming Pollution, 2023.

[383] Arancibia, Regulatory Science and Social Movements: The Trial Against the Use of Pesticides in Argentina, 2016.

[384] PAN International, The Permanent People's Tribunal Session on Agrochemical Transnational Corporations, 2011.

[385] Runnymede Trust, Reparations, 2025.

[386] World Benchmarking Alliance, Food and Agriculture Benchmark. Accessed July 2026.

[387] Biovision, B-ACT: Business Agroecology Criteria Tool. Accessed July 2026.

[388] Agroecology Coalition, Welcome to the Agroecology Finance Assessment and Tracking Tool, 2026.

[389] ChemSec, Investor Initiative on Hazardous Chemicals (IIHC). Accessed July 2026.

[390] ShareAction, Investors Press for Global Action On Toxic Chemicals as Pollution Crisis Escalates, 2025.

[391] IFOAM – Organics International, Training. Accessed July 2026.

[392] FAO, Agroecology Knowledge Hub, 2020.

[393] PAN Asia Pacific, International People's Agroecology Movements, 2025.

[394] ShareAction, Investors Press for Global Action on Toxic Chemicals as Pollution Crisis Escalates, 2025.

[395] IFOAM – Organics International, Participatory Guarantee Systems. Accessed July 2026.

[396] IFOAM – Organics International, A Global Overview of Participatory Guarantee Systems. Accessed July 2026.

[397] European Commission, Corporate Sustainability Due Diligence. Accessed July 2026.

[398] PAN UK, Pesticide-Free Towns Campaign, 2017.

[399] PAN North America, California Policy: Recap & Updates, 2026; New Rule Puts Limits on Pesticide Use Near Schools, 2017; New California Law Gives Farmworkers a Voice on Pesticide Policy, 2023.

[400] EFFAT, EFFAT Reaction to Sustainable Use of Pesticide Regulation, 2022.

[401] Chamot and Manaouil, Compensation System for Pesticide Exposure, 2023.

[402] SEWA, Self Employed Women's Organization. Accessed July 2026; SEWA, SEWA's Building Cleaner Skies Campaign, 2026.

[403] ActionAid, Rooted in Resistance Land Grabs, Climate Crisis and Corporate Power: Women's Resistance and Leadership. Accessed July 2026.

[404] FAO, Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. Accessed July 2026.

[405] WFFP, WFFP Coordinating Committee Meeting Underway on Pari Island, Indonesia, 2026.

[406] WFFP, World Forum of Fisher Peoples, 2026.

[407] UN Human Rights Council, Report of the Special Rapporteur on the Right to Food, 2017.

[408] UN General Assembly, Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment, 2021.

[409] OHCHR, The Impact of Climate Change on the Right to Food. Accessed July 2026.

[410] OHCHR, UN Declaration on the Rights of Peasants: UN Experts Call for Action Ahead of Anniversary, 2022.

[411] OHCHR, UN Declaration on the Rights of Indigenous Peoples, 2007.

[412] FIAN, A Just Transition to Agroecology, 2023.

[413] OHCHR, Open-Ended Intergovernmental Working Group on Transnational Corporations and Other Business Enterprises With Respect to Human Rights. Accessed July 2026.

[414] Biovision, Biopesticides Beyond the Hype, 2025.

[415] GRAIN, Corporate Bioinputs: Agribusiness's New Toxic Trap, 2024.

[416] Taylor and Reeves, The Corporate Capture of Biopesticides, 2026.

[417] Mawcha et al., An Overview of Biopesticide Regulatory Frameworks in Selected Countries in Southern Africa, 2025.

[418] Global Collaboration for Resilient Food Systems. Accessed July 2026; Global Collaboration for Resilient Food Systems, Botanical Pesticides. Accessed July 2026; Global Collaboration for Resilient Food Systems, Soil Health. Accessed July 2026; Global Collaboration for Resilient Food Systems, A Review of the State of Knowledge and the Use of Liquid Ferments and Biol in the Andes, 2022.

[419] Luig et al., "Green" Fertilizer in Africa Is No Substitute for an Agroecological Transition, 2025.

[420] French Ministry of Agriculture and Food Sovereignty, France's "EGAlim" and "Climate & Resilience" Legislation: Provisions Applicable to Institutional Catering, 2022.

[421] Pagliarino et al., Opportunities for and Limits to Cooperation Between School and Families in Sustainable Public Food Procurement, 2021.

[422] Matope, Mexico Innovates School Meals and Tightens Regulation to Promote Good Nutrition, 2024.

[423] Center for Good Food Purchasing, FAQs. Accessed July 2026.

[424] Center for Good Food Purchasing, History. Accessed July 2026.

[425] Presidência da República, Lei Nº 11.947, De 16 de Junho de 2009, 2009. (Translation: Law number 11.947, of 16 June 2009); Fundo Nacional de Desenvolvimento da Educação, Programa Nacional de Alimentação Escolar (PNAE). Accessed July 2026. (Translation: National Education Development Fund, National School Food Program.)

[426] The Rockefeller Foundation, Rockefeller Foundation Supports Brazil-Led Food Solutions to Nourish People at COP30, 2025.

[427] Oates and Cohen, Assessing Diet as a Modifiable Risk Factor for Pesticide Exposure, 2011; Curl et al., Organophosphorus Pesticide Exposure of Urban and Suburban Preschool Children With Organic and Conventional Diets, 2003; Bradman et al., Effect of Organic Diet Intervention on Pesticide Exposures in Young Children Living in Low-Income Urban and Agricultural Communities, 2015; Hyland et al., Organic Diet Intervention Significantly Reduces Urinary Pesticide Levels in U.S. Children And Adults, 2019.

[428] Friends of the Earth, Organic Works. Accessed July 2026.

[429] Foodrise, The Ten Point Plan for Plant-Rich Diets. Accessed July 2026.

[430] Leip et al., Appetite for Change: Food System Options for Nitrogen, Environment & Health, 2023.

[431] Coller Animal Law Forum, Ultra-Processed Animals. Accessed July 2026.

[432] Soil Association, Peak Poultry: Why the UK Must Eat and Produce Less Chicken. Accessed July 2026.

[433] Ahern et al., Locally-Procured Fish Is Essential in School Feeding Programmes in Sub-Saharan Africa, 2021.

[434] Fonden for Plantebaserede Fødevarers, Plant-Based Food Grant. Accessed July 2026.

[435] Danish Plant-Based Diplomacy, More Plants with Danish Plant-Based Diplomacy. Accessed July 2026.

[436] Global Alliance for the Future of Food, Cultivating Change: A Collaborative Philanthropic Initiative to Accelerate and Scale Agroecology and Regenerative Approaches, 2023.

[437] Global Alliance for the Future of Food, Catalyzing Finance and Action for Regenerative and Agroecological Food Systems Transitions (RAFT), 2025.

[438] IFOAM – Organics International, The World of Organic Agriculture: Statistics and Emerging Trends 2026, 2026.

[439] France in English, French National Assembly Approves Increased Tax Credit for Organic Farming in 2026 Budget, 2025.

[440] IFOAM – Organics International, Participatory Guarantee Systems (PGS). Accessed July 2026; IFOAM – Organics International, A Global Overview of Participatory Guarantee Systems. Accessed July 2026.

[441] IPCC, Sixth Assessment Report, 2021–2023.



Photo credit: Hamish John Appleby_ IWMI, Ghana

Acknowledgements

We are grateful to the numerous individuals and organizations who provided their time and expertise in the planning and development of this work. We deeply appreciate the support and expertise of the contributors, reviewers, and project consultants, Taarini Chopra, Shailendra Yashwant, and Jack Thompson, who shaped the content and form of this report.

We extend our gratitude to Global Alliance members and the Global Alliance secretariat.

We extend our thanks to Tracy Bordian, who copy edited the documents, and The Ethical Agency who worked on the graphics, design, and layout. The Global Alliance secretariat remains responsible for the content of this report and any errors or omissions.

Report design by The Ethical Agency



Photo credit: L. Sharma _ Marchmont Communications, Zimbabwe

Photo credit: SELCO Foundation, and IKEA Foundation (Global Alliance Member)

www.futureoffood.org