Thought Leadership

Grow, move, eat, repeat

Transitioning agri-food from sustainability liability to asset

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Contents

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Executive Summary

The Green Revolution confounded Malthusian predictions of widespread food scarcity, but revolutions are rarely black and white. Today the food system generates detrimental impacts on health, climate, and nature—creating negative externalities to the tune of USD 15tr every year (2020 USD), or 12% of global GDP.[1] The agri-food industry is now entering a new phase—what we call, Green Revolution 2.0. This report analyzes the solutions that characterize it, and the role of capital providers in facilitating their development.

Green Revolution 2.0

A critical phase in the agri-food industry is emerging from the interaction of three macro trends:

1. **Global sustainability targets:** No industry substantially impacts both the climate and nature like agri-food, which drives up to 30% of emissions and at least 90% of deforestation.[2] The Paris Agreement and the Global Biodiversity Framework imply significant changes for the industry, and transition risks—like reducing fertilizer use or reforming subsidies—already exist.
2. **Food security:** The "global supply chain reset" and sustainability targets mean two things for food security. The first is doing more with less. For instance, recent spikes in energy prices raised fertilizer and food costs in many countries, putting pressure on farms to increase input efficiency. The second is a shift to closely scrutinizing how food is sourced. Countries that rely on only a few sources might face risks from failed harvests or geopolitical conflicts.
3. **Just transition:** The transition will be politically unsustainable if it comes at the cost of livelihoods, which could be adversely affected as farms improve productivity and reduce their need for labor. Recent modeling suggests sustainability goals could increase food prices by 30% by 2050 compared to current trends,[3] creating a dangerous tradeoff between sustainability and social goals, such as zero hunger by 2030 (Sustainable Development Goal 2).

These pressures imply fundamental changes regarding how the world grows, moves, and consumes food. Global sustainability goals will most likely act as the driving force behind how and what food is produced, given they require an immediate end to agricultural land expansion and a rapid shift to plant-based diets.

[1] Food System Economics Commission (2024), *Global policy report: The economics of the food system transformation*.
[2] Cerutti et al (2023), *Food system emissions: a review of trends, drivers, and policy approaches, 1990-2018;* Pendrill, F. et al (2022), *Disentangling the numbers behind agriculture-driven tropical deforestation,* Science.
[3] Food System Economics Commission (2024), *Global policy report: The economics of the food system transformation*.

Structurally unprepared

Yet, the agri-food industry is structurally unprepared to deliver sustainability goals smoothly—it is risk averse, cautious, and fragmented.[4] Its cash flow cyclicality; intensely price-driven dynamics; and uncertain, weather-dependent production cycles brew a general reluctance to invest in more efficient productive assets as well as research and development, keeping innovation rates low. Solutions are available, but enacting them to achieve a Net Zero, Nature Positive agri-food industry requires new dynamics: Calculated risk taking in a stable commercial environment; high innovation rates; and a willingness to adopt new technologies. Embracing these dynamics means farmers and companies can position themselves ahead of unfolding trends, capturing premiums as the industry transitions.

Solutions across three stages of the value chain: Grow, Move, Eat

Many solutions exist to improve sustainability across the three stages of the agri-food value chain—*Grow, Move, Eat*—but there are no silver bullets. A plausible path for the industry to achieve progress on sustainability goals is to deploy mature and investable solutions that provide a meaningful impact over the next decade and continue experimenting to bring other solutions to market.

The *Grow* stage generates most of the emissions and environmental impacts of the industry, which means it also presents a significant opportunity to improve sustainability. Solutions are grouped into improving on-farm efficiency, changing the production model, and adopting advanced tools. Precision agriculture offers the most substantial near-term benefits: It can dramatically increase input efficiency, yields, and is investable today—a "no brainer" if financing is available and affordable.

Improving sustainability in the *Move* stage centers on injecting flexibility into the supply chain, by either increasing the shelf life of food, or enabling food to move in response to demand, ultimately reducing food waste. Solutions include edible coatings and films, expanded and more efficient cold storage, and digital screening tools.

Finally, the decisions made by consumers and retailers in the *Eat* stage drive significant changes throughout the entire value chain. They do so by providing better information to each other, such as through dynamic pricing, or by encouraging better consumption habits, such as via nudges.

The role of capital markets

The financial industry's role in facilitating the agri-food industry's transition is the same as usual: Convening users of capital across the value chain and matching them with capital providers based on their risk-return preferences. However, what could change is how capital markets fulfill this function. We propose a three-pronged framework (*finance, convene, engage*) to provide a wide range of financial tools, such as UBS's partnership in Tanzania to deploy Outcome-based Nature Finance; convene stakeholders across the value chain to tackle information barriers, such as the FAIRR initiative, in which UBS is a member;[5] and leverage engagement with strategic stakeholders in the value chain (i.e., those occupying oligopolistic market positions, like large food companies and food commodity traders) to deliver sustainability priorities.

While capital markets can take more action, they are only an enabler and require public support. Traditional economic models assume that governments act when a market produces negative externalities; they should sit in the driver's seat to transform the agri-food industry.

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[4] European Investment Bank, (2019), *Feeding future generations: How finance can boost innovation in agri-food*, Report for the European Commission.
[5] The Fair Animal Investment Risk and Return (FAIRR) Initiative is an investor network that raises awareness of the ESG risks and opportunities in the food sector.

1. Green Revolution 2.0

At a glance

- The Green Revolution mostly solved the food quantity problem, but today's food system continues to impose substantial costs on climate, nature, and health.
- We believe Green Revolution 2.0 is likely to emerge from the interaction of three macro trends: global sustainability targets, food security, and a just transition.
- Yet, the agri-food industry, which is risk averse, cautious, and fragmented, is unprepared to transition at the speed and scale demanded by sustainability goals.

The modern agri-food industry is a product of the Green Revolution. In the early 20th Century, technological innovations drastically improved global agricultural yields, breaking the historical correlation between population growth and the expansion of agricultural land. As volume expanded, globalization increased how far and fast agricultural commodities could travel. The Green Revolution solved the problem of providing enough food for a growing population, but its legacy also includes the unanticipated (and undesirable) impacts it had on health, climate, and nature.

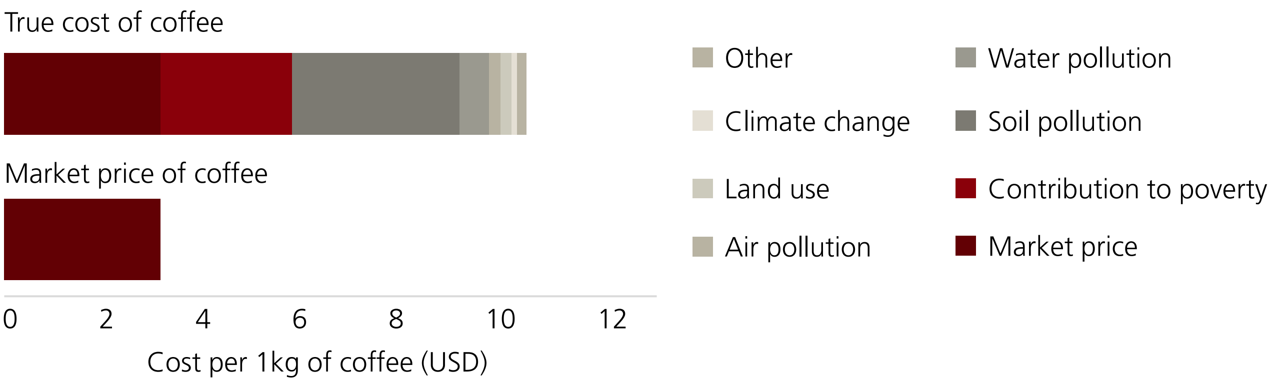
- **Health:** Consumers' diets across the globe are more homogenized than ever: High in fat, sugar, and salt. The Green Revolution contributed to this by changing what is grown, but it also resulted from the response of food companies and consumers over time. These diets promote non-communicable diseases, such as heart disease. Global adult obesity rates doubled between 1990 and 2022, from 25% to 43%,[6] and diabetes rose from 3% to 6% of adults over a similar period.[7]
- **Climate:** Food is second only to fossil fuels as a human-made driver of climate change, generating roughly 20–30% of global greenhouse gas (GHG) emissions.[8] Roughly two thirds of these emissions occur before the farm gate. The remaining third are emitted between "farm and fork" through the process of moving food from farms to storage and shops, and eventually kitchen tables. Agri-food's short-term climate impact is also higher than that of other industries as it emits 60% of global methane and 84% of nitrous oxide—both gases with substantially higher short-term warming potential than carbon dioxide.[9]

[6] World Health Organization, (2024), *Obesity and overweight: Overview.*
[7] The statistic is age-standardized, and over 95% of diabetes cases are Type 2; see Ong, K. et al., (2023), *Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: A systematic analysis for the Global Burden of Disease Study 2021,* The Lancet.
[8] Based on the 2010–2018 average from Cerutti et al., (2023), *Food system emissions: A review of trends, drivers, and policy approaches, 1990–2018*; The exact share depends on what one includes in the definition of the agri-food system.
[9] Ibid.

- **Nature:** The agri-food industry is responsible at least 90% of global deforestation.[10] Once farms become established, they inevitably put pressure on natural capital, which is only a problem if they grow food unsustainably. Of particular concern are irresponsible fertilizer application leading to nitrogen pollution; poor farming techniques, such as intensive tilling which generates soil degradation; and overuse of freshwater, given that agriculture globally consumes 70% of it.[11]

These impacts are interconnected and generate costs, which the shelf price of food ignores. Looking at individual commodities can make the costs feel tangible, as in the case of coffee, whose production creates negative externalities which, if added, would triple its price (Figure 1).

Figure 1: The market value of coffee hides the true cost of its production
The production process creates several negative externalities, which if included, would triple coffee's price



Source: Solidaridad and True Price (2019); UBS

Scaling the true cost of food production up to the global level shows the full extent of the agri-food industry's negative externalities (Figure 2). A recent analysis estimated the industry generates net economic costs of USD 15tr every year, the equivalent of 12% of global gross domestic product (2020 PPP).[12] It also estimated that between USD 200–500bn is required to reverse these externalities, creating a windfall of USD 5tr in net economic benefits while aligning the sector with the Paris Agreement's goal to limit warming to well below 2°C above preindustrial levels.[13]

1.1. A new Green Revolution

The agri-food system is entering a new phase of development—what we term Green Revolution 2.0[14]—through the interaction of three macro trends.

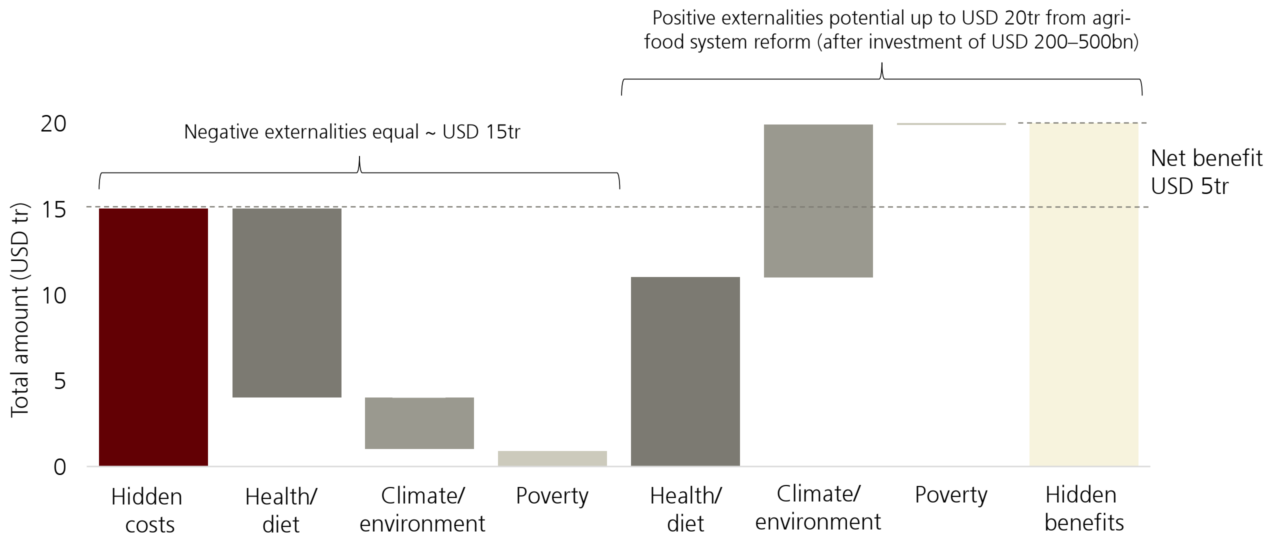
- **Global sustainability goals:** The Paris Agreement (Net Zero by 2050) and the Global Biodiversity Framework (Nature Positive by 2050) create significant transition risks for the agri-food industry. In order to achieve the targets proposed in these agreements, consumers need to reconsider their diets and incorporate more plant-rich options—a consumption tipping point that presents commercial risk for producers. In addition, regulatory changes that mandate sustainable farming

[10] Pendrill, F. et al (2022), *Disentangling the numbers behind agriculture-driven tropical deforestation,* Science.
[11] Water scarcity is explored in more detail in UBS Sustainability and Impact Institute (2023), *Running dry: Enhancing the resilience of APAC cities to water stress.*
[12] PPP = Purchasing Power Parity; see Food System Economics Commission, (2024), *Global policy report: The economics of the food system transformation*.
[13] Figure 2 does not reflect the investment required, which breaks down as: USD 200bn in health/diet and climate/environment solutions; and a sizable USD 300bn "safety net" to offset food price increases; see FSEC, (2024), *Global policy report: The economics of the food system transformation*.
[14] Building on work elsewhere, such as Pingali, P. (2012), *Green Revolution: Impacts, limits, and the path ahead,* PNAS.

techniques including, for example, limiting harmful fertilizers in food production are needed. None of this will be easy to implement, as seen from the 2023 farmers' protests in the Netherlands due to the rapid introduction of nitrogen regulations. If sustainability targets are missed—based on current trends the industry is aligned to 2.7°C of warming[15,16]—the physical risks this gives rise to will affect agriculture more than other industries. Farming has evolved to suit growing conditions, making weather a core part of its production function. Changing weather will make the supply of most, although not all, core commodities more volatile, generally reducing global yields.[17]

Figure 2: The agri-food industry generates significant negative externalities

The industry's negative impact on nature, climate, health, and poverty generates economic costs of USD 15tr annually. But investing up to USD 500bn in solutions across these categories could yield USD 5tr annually.



Source: Food System Economics Commission (FSEC) (2024); UBS

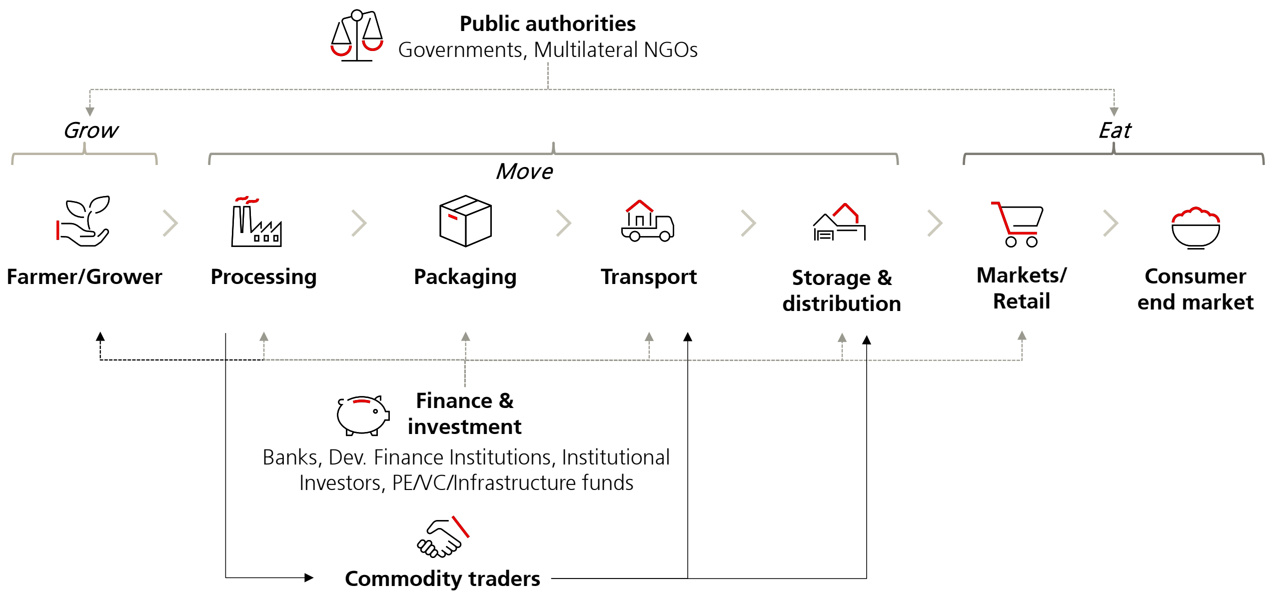
- **Food security:** If previously producing enough food was the primary goal, in future it will be paramount to do more with less. Recent spikes in the price of energy led to an increase in fertilizer and subsequently food costs in many countries, creating an emphasis on deglobalization, and putting pressure on farms to improve input efficiency. Sustainability targets just add to this demand, from the use of water and agrochemicals to land, because a nature-positive world will undeniably be a land-constrained one. Moreover, while globally integrated supply chains enhance food security by providing more trading partners, they also create new risks. Egypt, for instance, initially struggled to source enough food after the outbreak of war because it is the largest importer of wheat globally, and over 80% of its imports come from Russia and Ukraine.[18]
- **Just transition:** Sustainability targets and the drive for food security pose many socioeconomic risks, particularly for jobs and food prices. Perhaps surprisingly, forecasts suggest the impact of Net Zero on agri-food jobs could be marginally positive.[19] Not all farm jobs are lost as productivity

[15] Between 2020 and 2100, compared to 1850 to 1900; FSEC, (2024), *Global policy report: The economics of the food system transformation.*
[16] Smil, V., (2022), *How the world really works: A scientist's guide to our past, present, and future,* Penguin Books.
[17] Hasegawa, T. et al., (2022), *A global dataset for the projected impacts of climate change on four major crops,* Table 1. Scientific Data.
[18] Imports fell 24% in the first half of 2022 vs. the same period in 2021, and import prices rose by 43%; see USDA and FSA, (2022), *Decline in Ukraine wheat imports drives Egypt to diversify its suppliers;* Abay, K. et al., (2022), *Russia-Ukraine crisis poses a serious threat to Egypt—the world's largest importer of wheat.*
[19] McKinsey forecasted a net gain of 27 million jobs (roughly 4% of the current agricultural workforce), largely due to increases in demand for bioenergy and poultry in their scenario; McKinsey, (2022), *The net zero transition: What it could cost, what it could bring.*

rises. Instead, they "move down" the value chain into the processing and retail segments.[20] Ensuring labor can move throughout agri-food value chains should be a priority to minimize the loss of livelihoods at the farm level. Food price inflation is the real elephant in the room. Reducing emissions from farming entails large upfront capex, while environmental goals imply no further expansion of farmland. This puts upward pressure on food prices; a plausible scenario estimated that agricultural commodity prices could additionally rise 30% by 2050 compared to a baseline current trends scenario (2020 PPP).[21] Recent modelling focused on Asia concluded a net zero scenario is likely to increase real food prices by 25% by 2050.[22] Higher prices might incentivize less waste, but without safety nets, a dangerous tradeoff exists between environmental and social goals such as zero hunger by 2030.

We believe global sustainability goals will act as the dominant driver of change. It is an inescapable fact that the transition's impact will be felt across the whole value chain, from producers to consumers (Figure 3). Plant-based diets serve as an example; they require a move away from livestock farming in the upstream, new types of infrastructure to store food in the midstream, and changes to the food habits of consumers in the downstream.

Figure 3: The agri-food value chain across three stages: Grow, Move, and Eat



Source: UBS

1.2. Structurally unprepared

Yet, we believe the agri-food industry is structurally unprepared to deliver on sustainability goals. A review of Europe's farming industry by the European Investment Bank concluded it is risk averse, cautious, and fragmented.[23] Its cashflow cyclicality; intensely price-driven dynamics; and uncertain, weather-dependent production cycles brew a general reluctance to invest in more efficient productive assets and research and development, keeping innovation rates low. The average age of farmers is

[20] Ambikapathi, R. et al., (2022), *Global food system transitions have enabled affordable diets but had less favorable outcomes for nutrition, environmental health, inclusion, and equity,* Nature Food.
[21] FSEC, (2024), *Global policy report: The economics of the food system transformation.*
[22] From 2020 base; See P63, Fig. 3.18 in Asian Development Bank (2023), *Asia in the global transition: Asian development outlook 2023 thematic report.*
[23] European Investment Bank, (2019), *Feeding future generations: How finance can boost innovation in agri-food*, prepared for the European Commission.

over 60 in many developed markets, further reducing innovation uptake.[24] While there are pockets of more innovative farms, we believe this conclusion extends to the majority of agrifood submarkets—particularly those dominated by smallholder farmers.

Solutions are available, but enacting them to achieve a Net Zero, Nature Positive agri-food system requires new dynamics: calculated risk taking in a stable commercial environment; high innovation rates; and a strong willingness to adopt new technologies. This report analyzes promising solutions at three stages in the agri-food value chain, *Grow, Move, and Eat,* before outlining the role of capital markets and investors in facilitating their development and deployment.

[24] International Fund for Agricultural Development (2019), *How old is today's farmer in the developing world?*

2. Grow, Move, Eat

At a glance

- Most of the agri-food industry's emissions and environmental footprint lies in the upstream *Grow* stage, which is also where over half of the industry's venture capital financing flows.
- The *Move* stage receives less funding than any other part of the value chain. Solutions here focus on lowering emissions from infrastructure and improvements in transparency.
- The *Eat* stage aims to change consumer behaviors, but little investment flows to solutions focused on sustainability.

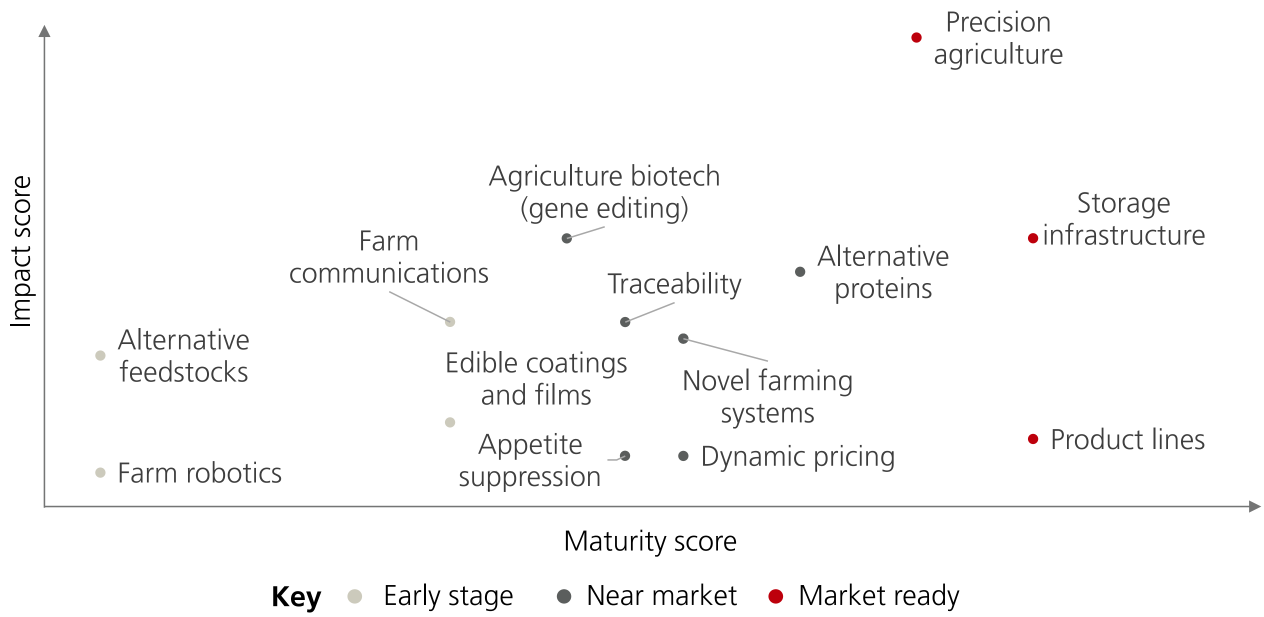
A lot of solutions are on the table to turn the agri-food industry from a sustainability liability into an asset. However, a conclusion from our research is that there are no silver bullets (Figure 4). Nothing ticks all the boxes—lowering emissions and environmental impacts, while maintaining food security and minimizing food prices. The state of several solutions is uncertain, most face technological barriers, such as high production costs and uncertain scalability, as well as social barriers, like untested public acceptability. Others are mature, investable, and offer high impact today, such as precision agriculture, which lowers the operational costs of farms as well as their sustainability footprint.

Scoring technologies against their maturity, defined as their Technology Readiness Level, and their potential climate and environmental impacts helps to make sense of the technology landscape (Figure 4). The most plausible path for the industry to make progress on sustainability goals is to deploy mature and investable "market ready" solutions that offer a high impact in the 2020s. "Near market" technologies are close to scaling and offer medium to high impact, but they face barriers, ranging from technological readiness to public acceptability, which means we do not expect them to have a major impact until the 2030s.

The final group, "early stage," are nascent solutions and unlikely to have a widespread impact on the industry's sustainability goals until they mature further, within an uncertain timeframe. Venture capital (VC) and other high-risk-appetite funding will be important for these technologies; fortunately, there is already a booming market (Figure 5).

Figure 4: Aim for high maturity, high impact solutions

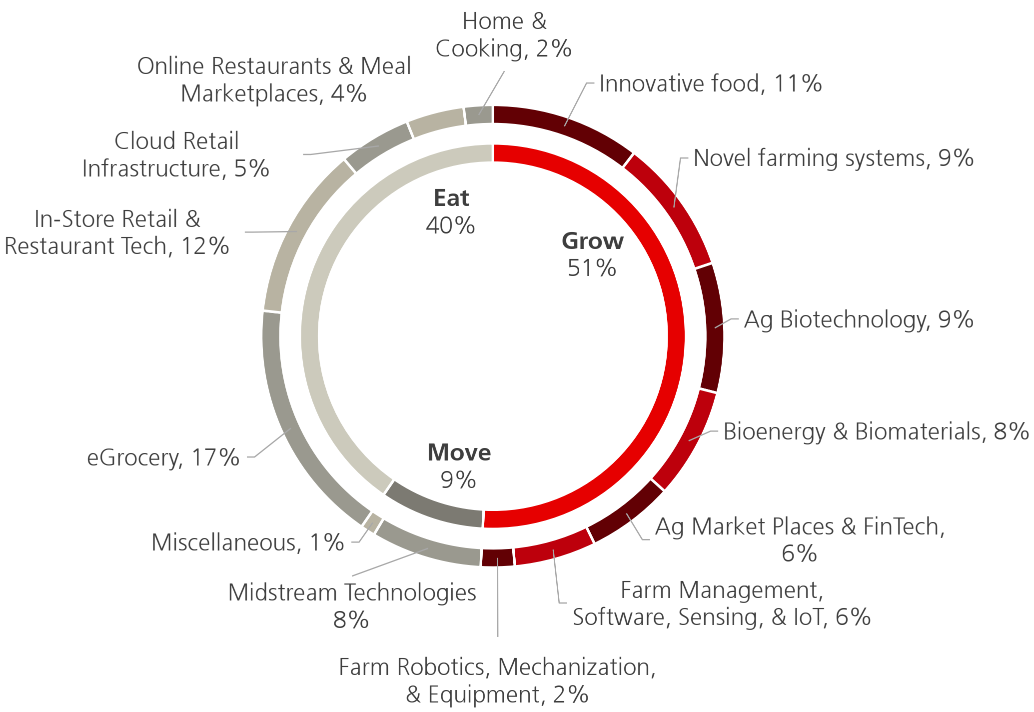
Deployment of market-ready solutions such as storage infrastructure and precision agriculture should be an immediate priority for capital markets



Notes: Some solutions included later in the report are not included in this graph due to the difficulty of scoring them; Maturity is defined by a qualitative score against the "Technology Readiness Level" framework; Impact is defined as a technology's contribution to global sustainability goals through a weighted average score across five indicators: two focused on climate (potential GHG abatement potential by 2050, and adaptation), and three environmental (nitrogen and phosphorous flows, freshwater consumption, and land use change). Scoring was informed by a literature review (particularly various Marginal Abatement Cost Curves for climate indicators), and expert discussions.
Source: UBS

Figure 5: The "Grow" stage attracts over half of VC investment in the industry

Most of the emissions and environmental impacts of the industry are generated at this stage.



Source: AgFunder, Temasek, and Global Ecosystem Partner (2023); UBS

Our analysis highlights the uncertainty surrounding how Green Revolution 2.0 will unfold, but it also presents a wide range of opportunities. Farmers and companies can position themselves ahead of trends by adopting and testing new solutions, capturing premiums in different forms, such as production efficiencies or higher demand for their produce. They will also be in an advantageous position as the industry transitions toward a Net Zero, Nature Positive state, through better familiarity with solutions and practices as they become the norm rather than an exception. The following section gives a sense of the sustainability challenge and solutions across the value chain.

2.1. "Grow" solutions

Almost three quarters of the agri-food industry's GHG emissions are generated at the farm level—43% from on-farm activities, and 25% from land use change.[25] The environmental impacts are also mostly linked to growing food, from the conversion of wild land to farmland, and on-farm pollution. This also means the upstream links in the value chain present a significant opportunity to make progress on sustainability goals, through improving on-farm efficiency, changing models of cultivation, and adopting advanced tools.

On-farm efficiency

Farm mechanization technologies improve resource management through precision agriculture, and could be complemented by farm robotics in the future. Emerging mechanizing solutions include targeted spray systems, and automated weeders that learn to spray and weed specific spots in response to real-time conditions (Box 1). However, as each field/crop is unique, the technology is not mature for full automation. The technologies also tend to be quite expensive, limiting their uptake given the general fragmentation of the industry across many small operators. And in areas with surplus and relatively cheap labor, automation technologies make less economic sense for farms, locking them out of the market.

Box 1: Farm-ng

Farm-ng is a California-based start-up that focuses on creating bespoke robots for agricultural work, as well as related analytics and integration with other technology, such as mobile apps. The company is making modular robots specialized to context, such as for a specific crop or terrain. The goal is for the robots to operate autonomously for a range of agricultural tasks, such as planting or harvesting crops, introducing efficiencies that reduce manual labor, maintenance, and fuel costs.

Farm communications cover remote sensing and in-ground sensors that automatically and continuously monitor key production variables, like soil conditions, in minute spatial and temporal detail, reducing costs. Fasal, an Indian startup, provides an Internet of Things solution through a series of measurement and communication devices placed on a pole, which communicate with models in the cloud. The devices measure micro conditions above and below the soil, which in combination with weather data, alert farmers via their phone with crop-specific advice, such as optimizing water and pesticide use.

[25] Figures are the average of agri-food's emissions between 2010 to 2018 from Crippa et al. (2023).

Changing models of cultivation

Novel farming systems, like vertical farms, produce food inside artificial environments. They tend to provide nutrients to plants in mediums other than soil, such as water (hydroponic systems) or air (aeroponic systems). They are highly resource efficient and use very few non-energy inputs compared to conventional farming. Pest management and disease outbreaks are also easier to control. Their output per unit of land is higher than conventional farming, all while using fewer resources. Owing to their proximity to cities, often residing within them, they generate lower transport and storage impacts.

However, their sustainability benefits are not black and white. Few empirical studies compare their effects with a baseline, making apples-to-apples comparisons with conventional farming difficult.[26] Most studies also agree that vertical farms today produce higher emissions than conventional farming due to their energy intensity. When factoring in the land footprint of the renewable power assets they rely on, they do not represent an efficient use of land in many climates; one study found that vertical farms tend to use more space than open-field vegetable farming in warmer climates.[27] Their sizable capital and operating expenditures keep production costs high, ultimately increasing food costs.

Cooperative models, where organizations group together to share capital and knowledge rather than operating in siloes, offer several advantages. Their sustainability benefits are based on economies of scale, a positive association with the diffusion of sustainability practices (Box 2). Farmers and other stakeholders co-invest in and share capital-intensive productive assets, such as efficient spraying systems, and buy inputs in bulk. This reduces upfront costs for new assets and green inputs—a significant barrier to adopting new technologies across all markets, but particularly in low-income countries.[28]

Box 2: Amul, a brand that revolutionized India's milk industry

In the 1940s, India's fragmented dairy farmers faced a reliance on middlemen, unfair prices, and limited access to international markets. Amul established itself as a leading milk brand by operating under a cooperative model, rather than as a corporate entity. Today, it is owned and governed by 3.6 million milk producers, directly tackling the fragmented nature of India's milk industry. It gave smallholder farmers better access to inputs on international markets, and at lower prices. This increased the industry's capacity to reinvest in new capital inputs, enabling the adoption of more efficient technologies. It also improved production techniques through information transfer and formal structures, such as better grading and sorting of milk, enforced by centralized technical experts.[29]

Alternative proteins include techniques to produce protein-rich foods that aim to mimic conventional meat products. They include plant-based meat, biomass fermentation (using microorganisms as the bulk of protein in products), and precision fermentation (using the products of microorganisms, such as enzymes, as specialized ingredients). By substituting demand for meat, they avoid additional emissions and land clearance, thereby offering sustainability benefits. Lab-grown meat is a more nascent area, owing to tough economics and technological barriers. As it matures it may also increasingly face regulatory headwinds (along with other alternative proteins); several states in the US

[26] Bunge, A. et al., (2022), *A systematic scoping review of the sustainability of vertical farming, plant-based alternatives, food delivery services and blockchain in food systems,* Nature Food.
[27] Weidner, T. et al., (2022), *Regional conditions shape the food–energy–land nexus of low-carbon indoor farming,* Nature Food.
[28] Candemir, A. et al., (2020), *Agricultural cooperatives and farm sustainability – A literature review,* Journal of Economic Surveys.
[29] Parwez, S., (2017), *Cooperative-led contract farming in India: A case study of Amul,* Journal of Cooperative Studies.

have already restricted its sale or added stringent labeling obligations.[30] Although companies offer several commercialized products today, their prices remain high, and manufacturing processes face technological barriers to operating at large scales.[31]

Regenerative agriculture is an approach to farming that prioritizes environmental benefits as well as yields. Generally, it refers to certain practices that lead to more favorable environmental outcomes, such as no tillage, or using cover crops to improve soil health. 50 of the largest 79 global food and retail giants mention it in their disclosures. However, few companies detail what passes for regenerative agriculture, or have targets, and so its sustainability benefits—while anecdotally positive—remain uncertain.[32] There is also no universal gauge to determine whether it leads to higher or lower yields; often, it comes down to what techniques a farmer is using, how, and the agroecological region they operate in.[33] The knock-on effect is that regenerative agricultural solutions can have uncertain cash flow impacts on farms, and so the jury is out on their investability.

Advanced tools and inputs

Biologicals are natural alternatives to traditional agricultural inputs, typically including biopesticides and biofertilizers. They are applied to crops via sprayers or irrigation systems, typically in combination with conventional inputs. Generally, they help to maintain healthy soil biology and reduce agrochemical run off.[34] Still, there are tradeoffs. Current issues include high costs, sometimes low efficacy, and uncertain effects across different settings. Most farmers view them suspiciously too, limiting adoption.[35] Regardless, regulations like the EU's European Green Deal, which view traditional agrochemicals less favorably, imply growth potential.[36]

Green ammonia is produced in the same way as regular ammonia, but it obtains key ingredients—hydrogen and nitrogen—through "clean processes," rather than conventional production (like natural gas).[37] Fertilizers are crucial inputs to maintain yield improvements, but they account for roughly 5% of global emissions.[38] Decarbonizing ammonia can substantially reduce agri-food's emissions, as well as those in many other industries where ammonia can displace fossil fuels, such as shipping. However, green ammonia makes up just 0.01% of ammonia production today, mostly due to the high cost of producing green hydrogen.[39] Yara, a Norwegian fertilizer company, is commissioning pilot plants for green ammonia, as well as securing ammonia volumes through offtake agreements from partners with plentiful renewable power from wind or solar farms.[40] This tackles green ammonia's high costs by providing the power project a reliable cash flow, and Yara with a steady supply of green ammonia, improving project economics for both sides.[41]

Agriculture biotechnology changes the attributes of organisms to improve agricultural productivity, efficiency, and resilience. Screening tools, which identify desirable crop and animal traits on a genetic level, enable targeted selective breeding and gene editing. Semex, a gene editing company,

[30] Reynolds, M., (2024), *States are lining up to outlaw lab-grown meat,* Wired.
[31] Wood, P. and Tavan, M., (2022), *A review of the alternative protein industry,* Current Opinion in Food Science.
[32] The Fair Animal Investment Risk and Return (FAIRR) Initiative, (2023), *The four labours of regenerative agriculture: Pacing the way towards meaningful commitments.*
[33] Khangura, R., (2023), *Regenerative agriculture—A literature review on the practices and mechanisms used to improve soil health.*
[34] Environmental Defense Fund, (2023), *Agricultural technology discovery report.*
[35] A survey in the US found at least 65% of farmers need more information before they would adopt them; Farm Journal Editors, (2019), *The biologicals race is on*; Non-representative survey of 672 growers in the United States.
[36] Mottram, N., (2023), *Biologics are the future for agriculture, but collaboration will drive commercial development and success,* Cambridge Consultants.
[37] Typically, hydrogen is obtained via electrolysis powered by renewable energy, and nitrogen from the air using an air separation unit.
[38] Gao, Y. and Cabrera Serrenho, A., (2023), *Greenhouse gas emissions from nitrogen fertilizers could be reduced by up to one fifth of current levels by 2050 with combined interventions,* Nature Food.
[39] IRENA, (2022), *Innovation outlook: Renewable ammonia.*
[40] Yara (2023), *Yara integrated report 2023: Building resilience and a nature-positive food future, P2.*
[41] E.g., Bloomberg, (2024), *Yara inks rare long-term deal for green ammonia from Acme.*

introduced a gene solution that can reduce methane emissions from cows by up to 30% by 2050[42]—a substantial potential reduction given livestock produce 40% of agri-food's emissions.[43]

2.2. "Move" solutions

Improving sustainability in the midstream of the value chain is all about adding flexibility into how food moves. Solutions that make it easier for food to travel through the supply chain, by either increasing its shelf life, or adding flexibility to the supply chain, ultimately reduce waste.

Edible coatings and films extend the shelf life of products by forming a protective layer over food, reducing exposure to oxygen and moisture. They reduce waste while maintaining quality. Bio-nanocomposite films, which process natural substances (such as chitosan from the shells of shellfish) into nanoparticle films are an emerging area. Films can also be made from other food fibers enhanced with gelatin. The main limiting factor is ensuring novel coatings are non-toxic and safe to consume.

Cold storage extends the quality and shelf life of perishable goods and adds flexibility to the value chain by creating "cushioning" between farm and fork. This infrastructure receives less attention from financial markets than other solutions,[44] and is not novel, but its importance is growing as demand for e-commerce and perishable food grows (both of which require more flexible supply chains). Building out storage capacity will be a key part of making progress toward the industry's sustainability goals. On the flipside, cold storage can be energy-intensive, made worse by older, inefficient infrastructure.[45]

Digital screening seeks to replace the dominant practice of manually inspecting food products for quality and sustainability with modern digital technologies. ZoomAgri is an agtech startup operating in 25 countries that uses computer vision and AI to verify the exact variety of a commodity and assess its physical quality. Its technology produces accurate and reliable grain quality data at low cost, enabling more credible traceability than physical inspections alone. This technology could reduce emissions by moving goods more efficiently, although the benefits will likely be marginal. The real sustainability value lies in the transparency it creates.

2.3. "Eat" solutions

Consumer and retailer decisions impact what producers make, and how. Although there are fewer emissions or environmental impacts in the downstream end of the value chain, this means solutions at the *Eat* stage have the potential to drive significant changes throughout the whole value chain. Our conversations highlighted solutions in two areas: better information, and better consumption habits.

Better information

Dynamic expiration pricing enables food stores to change the price of food items in real time based on the likelihood an item might expire without being sold. The firm Wasteless provides an AI solution that makes pricing decisions based on time to expiration and variables that affects purchasing decisions. Digital labels update prices without any human intervention. This reduces waste by

[42] Semex, (2023), *Breeding the way to low methane cows.*
[43] Cerutti, N. et al., (2023), *Food system emissions: a review of trends, drivers, and policy approaches, 1990-2018,* Environ. Res. Letters 18.
[44] UBS, (2022), *Cold: The new warm? Cold storage to transform the industrial and logistics sector.*
[45] JLL, (2020), *Cold storage in the post-COVID economy. Interestingly, the average cold storage facility in the US is roughly 50 years old.*

improving supply chain management, lowering the amount of food that goes unsold, and optimizing the amount of food ordered to stores based on demand.

Forensic origin verification is an emerging field that uses the inherent chemical elements within all products to verify their origin. The chemical composition of all raw materials varies significantly, influenced by various environmental factors such as altitude and precipitation. Oritain, a New Zealand-based start-up, detects naturally occurring trace elements and isotopes in a product or raw material to ascertain its unique chemical 'fingerprint', which can be compared with the company's extensive chemical databases to verify its geographical origin. [46] This process creates transparency for downstream users; consumers can align their purchasing decisions with sustainability preferences; corporates can monitor supply chain policies; and regulators can verify compliance with new regulations (such as the EU Deforestation Regulation).

Better consumption habits

Visually imperfect "wonky" products would normally be discarded by supermarkets. In recent years, food retailers began relaxing their cosmetic standards and repurposing these waste streams as new product lines. Their sustainability benefits are difficult to quantify and probably low compared to interventions that reduce impacts on farms. However, the impact is undoubtedly positive as any prevented food waste avoids the impacts from waste disposal.

Appetite suppression drugs are a recent trend. Their impact on the agri-food industry is yet to materialize and remains highly uncertain. Known as GLP-1s, they have been used since 2005 to treat diabetes and obesity; they are highly effective at reducing appetite with recent estimates suggesting calorie consumption reduction by as much as 8%.[47] Some analysts speculate they pose a threat to the demand for food, particularly "snacking" foods, which could generate substantial *potential* sustainability benefits by reducing overconsumption, which could lower levels of obesity and related illnesses. However, it is uncertain whether adoption of such drugs will scale due to their high price, storage requirements, frequency of intake needed, uncertain long-term consequences, as well as supply constraints, although these are likely to ease over time. Marginally reducing calorie intake also does not address the root causes of agri-food's emissions and environmental issues, which are rooted in how food is produced, rather than just how much is produced.

Nudge solutions encourage altering behavior. Interventions have been widely trialed in the agri-food industry, with mixed effects. Their success depends on how well the solution is designed for the social context at hand. Some of the more successful interventions include changing the position of food in stores to encourage healthier purchases and providing consumers with smaller plates and trays.[48] The most successful and widely adopted nudge is food labeling; Chile, for instance, introduced mandatory labels for unhealthy foods in 2016, alongside complementary regulations, such as preventing the advertisement of unhealthy foods. Recent evidence from *The Lancet* suggests this led to tangible reductions in the consumption of calories (3.5%), sugar (10.2%), and sodium (4.7%).[49]

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[46] We interviewed Oritain in a recent publication; see UBS Sustainability and Impact Institute, (2024), *Chain reaction.*
[47] JP Morgan, (2023), *The increase in appetite for obesity drugs.*
[48] Harbers, M. et al., (2020), *The effects of nudges on purchases, food choice, and energy intake or content of purchases in real-life food purchasing environments: A systematic review and evidence synthesis,* Nutrition Journal.
[49] Taillie, L. et al., (2021), *Changes in food purchases after the Chilean policies on food labelling, marketing, and sales in schools: A before and after study,* The Lancet.

Interview 1

The right crops in the right places. Jessica Fanzo, Professor of Climate, Columbia University

Is there a trade-off between the quantity and quality of the world's food supply?

Always. Today's agriculture subsidies are geared towards quantity. A focus on quality is important to reduce global health problems that agriculture contributes to—undernutrition and obesity. What is considered a healthy diet is now common knowledge—fruits, vegetables, legumes, nuts, whole grains and less junk food. But we are at an impasse where there is a lack of consensus on how to fix food systems: agriculturalists want to produce more food to feed the world and make profit; the nutrition community wants us to diversify what we grow to improve the nutritional quality of diets; and the environmentalists want to ensure that the way we grow food is environmentally sustainable. Affordability is also a key issue; 3.1 billion people today cannot afford a healthy diet.

How has the global food palette and nutrition changed over time?

Our diet is more diverse than ever. Even 30 years ago, people would have never consumed the range of products they eat today. China consumes wine today, but this was never part of their traditional cuisine. Our diets are also more homogenized than ever. Whether this continues will be shaped by how technology and climate evolve. Look at alternative proteins: We may have to consume more of them as it becomes increasingly hard to raise livestock in a hot house world.

How do physical sustainability factors inform food security?

Context matters. Avocados are water-intensive; should we grow them in California? Space is becoming scarcer globally, yet 75% of farmland is for cattle and dairy—is this the best use of land? Maybe not, but then livestock are vital in landscapes where it is impossible to grow food, because they are incredible converters of grass into rich protein.

What are some successful and emerging interventions to improve food outcomes?

Free school meals are a real success story. The effectiveness of taxes varies; 120 countries tried taxing sugary beverages, which had mixed effects. Part of the issue is linking their affects to biological health outcomes; we know taxes impact purchasing decisions, but their impact on health needs more evidence. Systematic reviews found nudges that change food choices can work, but they struggle to scale and replicate. The latest trend is GLP-1 agonists being used as a weight loss drug for those who can afford it. While impactful, it sidesteps vital actions that need to be taken in food systems, such as ensuring access to healthy diets for everyone. It's also very hard to assess the sustainability impact of some technologies, like alternative proteins, because they typically operate behind closed doors.

How can we all contribute to enhancing food security and sustainability?

Consume fewer animal products. Even consuming animals with smaller carbon footprints helps. But what is tasty and sustainable at an affordable price point varies. We need to push industry to hit the sweet spot—affordable, sustainable food, that can be produced profitably. Reducing food waste can also make a big difference. Some behaviors to minimize waste include: avoid buying in bulk; check expiration dates; and utilize leftover foods to make other interesting dishes.

If you were made a national food tsar tomorrow, what would you do first?

Reform or reorient agriculture subsidies, so they provide economic incentives for the industry to grow a more diverse set of crops in environmentally sustainable ways.

3. The role of capital providers

At a glance

- Capital providers can enable the agri-food industry's transition through a three-part strategy: *finance, convene, engage*.
- They can provide a wide range of financial tools, convene stakeholders across the value chain, and align engagement activities with sustainability strategies.
- Finance is only an enabler, and there are areas where action by the rest of the value chain—public authorities, producers, big corporates, retailers, consumers—is required.

All transitions require capital to develop and scale solutions. The financial sector's role in facilitating the agri-food transition is in convening users of capital across the value chain, matching them with capital providers based on their risk-return preferences, and engaging with both to ensure best practices are broadly shared. We hone this down to *finance, convene, engage* (Figure 6).

Figure 6: Three strategies cover the structural bases of the agri-food industry

Finance is an enabler, and alongside other stakeholders in the value chain, it can promote sustainable practices

	Structural features of agri-food					
Strategies for the financial sector	Risk averse and cautious	Fragmented	Low innovation	Low uptake	Long cycles, need for 'patient capital'	Outsized influence of some stakeholders
Finance	✓	○	✓	✓	✓	○
Convene	○	✓	✓	✓	○	○
Engage	✓	✓	✓	✓	✓	✓

✓ Strategy relevant ○ Strategy not relevant

Source: UBS

3.1. Finance

Offering an extensive menu of financing options will be key to optimizing sustainability in the agri-food industry (Figure 7). First there is a wide range of balance sheets throughout the agri-food value chain, which creates a diversity of financing needs. A large European farm might be able to finance capital-intensive precision agriculture using debt finance on its own balance sheet, perhaps blended with public grants. But these tools might not work for a lone subsistence farmer in South Asia with no assets and thin margins to borrow against; instead, a cooperative model with philanthropic capital would be better suited. Financing options should also be as simple as possible, given that the complexity of novel green financing products reportedly hinders adoption by farmers.[50]

Figure 7: Debt finance dominates, but new financial instruments are emerging

To encourage uptake, green financing options should be simple and suitable for farmers' varied needs

	Traditional and well-established	Tested and growing	New and innovative
Non-repayable rewards	Grants and subsidies (public, philanthropic) Tax incentives	Municipal Agri. Watershed partnerships	Grants and subsidies scaled to public goods
Debt financing	Leasing Loans (inc. micro finance) Bonds Guarantees	Cooperative leasing Supply-chain trade finance Sustainable bonds and loans Sustainable leasing Blended finance (<USD 10mm)	Green revolving credit Soil-health operating loans Blended finance (>USD 10m) Sustainable supply chain trade finance
Equity financing	Private Equity / Venture Capital Listed equity	Food infrastructure funds Impact funds Natural capital / conservation funds	Blended finance Outcomes-based funds
Risk sharing	Crop yield insurance Agricultural derivatives	Incentive-based commodity pricing Parametric/index-based weather insurance	Post-application coverage endorsement Sustainability-linked crop insurance subsidy Sustainable reference price Parametric livestock insurance

Source: UBS

Second financing requirements vary based on the maturity of the solution. The deployment of mature, high impact solutions, such as storage infrastructure and precision agriculture, should be an immediate priority for capital markets. They tend to be readily financeable through conventional instruments, with well-known risk-return profiles, thus appealing to institutional investors. Less mature solutions with potentially substantial sustainability benefits, like alternative proteins and vertical farming, need to rapidly commercialize, develop business models that are viable over the long term, and scale. Capital providers with higher risk appetites, such as VC and specialist funds, will play

[50] Field to Market, (2021), *Financial innovations to accelerate sustainable agriculture: Blueprints for the value chain*, P. 17.

a crucial role in maturing and moving these solutions down the cost curve. New and innovative financial instruments need to be scaled for these types of solutions, such as blended finance, where innovative models exist, but a gap persists on large ticket sizes that make them appealing to institutional investors (Box 3).

Box 3: Blended finance: the Lindi-Morogoro project

Traditional financing may be unavailable for projects with uncertain cash flows. Blended finance offers an alternative approach; by deploying public or philanthropic funding via different channels, such as grants or concessional loans, projects can spread risk and attract more capital providers. Although climate-related blended finance deals reached a historic low in 2023, it remains an important financing route for many projects.[51] The UBS Optimus Foundation recently partnered with Village Climate Solutions, Reterra, and Tanzania Forest Conservation Group to generate carbon credits from protecting 220,000 hectares of forest. The project aims to generate over USD 20mm in carbon credit-derived cash flows over 12 years, enabling villages to avoid deforestation through actions including sustainable agriculture, such as multi-layer cropping. UBS provided an initial grant followed by an 'impact loan' that financed the avoided deforestation activities. The project is UBS's initial use of Outcome-based Nature Finance, which measures and prices co-benefits that voluntary carbon markets ignore, promoting transparency for funders and impact monetization for projects.

3.2. Convene

The financial sector can convene stakeholders to promote the deployment of sustainability solutions in the agri-food industry in three ways. First, it can connect innovators with capital providers. Agri-food industry VC firms typically have a holding period of 9 years, compared to 6 years for other industries.[52] This can make it difficult to find early-stage funding. By convening innovators and appropriate capital providers, the financial sector can help make suitable and mutually beneficial connections.

Second, capital can catalyze innovation uptake. Producers of food are generally slow to adopt innovations; capital providers have an opportunity to raise awareness regarding available solutions and generate progress toward sustainability goals in the process. For example, UBS recently partnered with EPFL and E4S to create engagement materials that highlight opportunities to decarbonize Swiss agriculture.[53] Another important example is local banks in developing markets, who act as conduits between international markets and (typically) informal commodity traders and smallholder farmers.

Last, there needs to be more knowledge sharing. What qualifies as best practice, or even standard practice, can get lost in translation as ideas travel. While corporates have embraced regenerative agriculture in their disclosures, there is no consistent definition of what it means. The FAIRR initiative, of which UBS is a member, recently convened stakeholders to evaluate how the market uses the concept, and where the pitfalls lie—an example of effective convening in practice.[54]

[51] Convergence (2023), *State of blended finance 2023: Climate edition.*
[52] European Investment Bank, (2019), *Feeding future generations: How finance can boost innovation in agri-food*, Prepared for the European Commission.
[53] See E4S and EPFL (2022), *Transformative projects: Decarbonization of the agricultural sector in Switzerland.*
[54] The Fair Animal Investment Risk and Return (FAIRR) Initiative is an investor network that raises awareness of the ESG risks and opportunities in the food sector.

3.3. Engage

Engagements are direct communications between investors with an investee on its management of certain areas. They aim to change company practices which are not aligned with shareholder interests. The financial community cannot engage every single farmer, but it can indirectly influence farm-level practices. Individual, oligopolistic companies have significant influence over the whole chain, therefore a strategic engagement approach could yield substantial overall industry benefits. Large companies that influence food value chains through pricing or procurement requirements, and commodity traders, who influence the flow and pricing of goods on a global scale, stand out.

The exact goal of engagement will vary depending on the financial firm, its strategy, and the investee. At a high level, two asks can apply to all engagements between investors and investees. First, adopt clear sustainability standards to promote best practices up the supply chain (such as Leading Harvest, an outcomes-based sustainability standard for farm management in which UBS is a founding member). Second, set out sustainability strategies that align with global sustainability targets. For example, the UN Food and Agriculture Agency recently created a decarbonization roadmap to 2050, which could provide industry milestones for any strategy.[55]

3.4. Finance alone cannot save the world

The financial sector is an enabler of progress, but it cannot deliver system change by itself in the presence of today's negative externalities. Its limitations lie in:

- **Public capital misallocation:** Agricultural subsidies often do not align with public sustainability goals but promote output for output's sake. One consequence is spraying excess fertilizer rather than investing in precision agricultural solutions. The World Bank recently estimated that 17% of nitrogen pollution in water can be attributed to the use of excess input subsidies.[56]
- **Unlikely commercialization:** Solutions that are necessary to meet public sustainability goals may struggle to scale economically with only private finance if they present no route to commercialization, requiring additional public support. One example is carbon capture, utilization, and storage, which is important to decarbonize GHG-intensive products like fertilizers.
- **Social and political questions:** Challenges such as encouraging consumers to shift their diets toward plant-based foods are public in nature, and most of the industry lacks the commercial incentives to solve them. Similarly, farming practices are often tightly correlated with public policy, particularly in regions that heavily subsidize food production. Necessary actions like changing subsidy regimes, or top-down regulation of fertilizer usage, often create political pushback.

Public authorities will need to be in the driving seat for the agri-food transition, given these limitations, but also because the industry spans many policy areas, including climate change, the environment, health, trade, and international relations.[57] Recent events imply they are taking the lead; at COP28, over 100 countries pledged to transform the food system for climate change, and a similar number made commitments to create "national food pathways" in 2021.[58]

[55] FAO, (2023), *The 1.5°C threshold: A global roadmap*.
[56] Damania, R. et al., (2023), *Detox development: Repurposing environmentally harmful subsidies,* P171.
[57] Bovarnik, A., (2024), *Food systems transformation: A whole of government approach to drive change,* United Nations Development Programme.
[58] COP28, (2023), *COP28 UAE declaration on sustainable agriculture, resilient food systems, and climate action;* UN (2021), *Press release: More than 100 countries sign up to develop national strategies for transforming food systems.*

4. Summing up

1. The Green Revolution solved one challenge—growing enough food—but many remain. Today's agri-food system imposes substantial costs on the climate, nature, and health, all of which are excluded from the shelf price of food items.

2. The agri-food industry is entering a new phase, Green Revolution 2.0, which will be shaped by sustainability goals, new ideas to address food price inflation, the drive to protect livelihoods and encourage the adoption of healthy diets. However, the industry is structurally unprepared to make the changes demanded by sustainability goals.

3. A lot of solutions exist to improve sustainability across the three stages of the agri-food value chain—*Grow, Move, Eat*—but there are no silver bullets. A plausible path for the industry to achieve progress on sustainability goals is to focus on deploying mature and investable solutions that offer a high impact in the next 10 years, and to continue experimenting and innovating to bring other solutions to market.

4. Capital providers can actively facilitate the development and deployment of solutions through a three-pronged approach: finance, convene, engage. However, finance is only an enabler, and delivering a Nature Positive, Net Zero agri-food system will require action across the whole value chain including by governments, producers, retailers, and consumers.

About the Institute

The UBS Sustainability and Impact Institute was founded in 2021 to contribute to the sustainability debate, with a focus on actionable and timely contributions. The Institute is a collaborative effort with sustainability experts from across UBS's business divisions. We strive to encourage objective and fact-based debate, provide new impulses for action, and identify innovations that will help shape our collective efforts and awareness about sustainability and impact.

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