In collaboration with
Boston Consulting Group

WORLD ECONOMIC FORUM

Mainstreaming Food Innovation:
A Roadmap for Stakeholders

WHITE PAPER

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Images: Getty Images

Contents

The role of emerging technologies in driving progress for humanity cannot be understated. This report, built on the founding principles of public–private cooperation of the World Economic Forum, provides a practical approach on how to harness the intelligent age in service of the most fundamental system that 8+ billion people today depend on: food. New and unusual collaboration frameworks, as demonstrated by the Food Innovation Hubs, are needed for these technologies to be an enabler of change for improved farmer economics, and positive impacts on climate, water and health.

Klaus Schwab, Founder and Chairman, World Economic Forum

Foreword

Tania Strauss
Head of Food and Water,
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Shalini Unnikrishnan
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Global food systems are facing unprecedented challenges. Demands on agriculture are growing, yet progressing degradation, increasing rates of malnutrition, water scarcity and biodiversity losses mean that transformation is imperative. This report highlights the critical role of innovation in food systems and provides a framework to mainstream it.

Solutions in food innovation that address socioeconomic and environmental challenges remain starkly underinvested. We present a framework to help promote cross-sectoral and systemic integration in food. We show how the World Economic Forum's Food Innovation Hubs are connecting the dots between technological developments in food and agriculture, stakeholder collaboration and policy support to transform how we produce, distribute, finance and consume food.

Innovation in food systems presents a significant opportunity for farmers, investors and corporates. However, success is determined by collective action to build food systems that can navigate the trade-offs, mitigate the unintended consequences and deliver on the promise of innovation, leaving no one behind.

We invite you to innovate, collaborate and invest in the future of food.

Executive summary

Combining efforts to source, shape and scale food innovation can mainstream and effectively derisk investments.

The food system as a whole is responsible for a third of greenhouse gas (GHG) emissions and 70% of freshwater use.[1] Food insecurity is rising, with one in 10 people globally suffering from hunger. Innovation in food systems has the power to mitigate these impacts and build a better food future for everyone. But although innovations are plentiful, the full impact potential is not being realized because they are not being adopted at scale. This white paper provides a roadmap for stakeholders to mainstream food innovations through a framework for ecosystem cooperation.

Innovations are being developed for every part of the food system. However, exits, overall investments and growth rates remain low, which sheds light on one aspect of the challenge. Significant barriers to the scaling of food innovation include high production costs per unit, complex regulatory environments, lack of co-creation, poor infrastructure and inconsistent demand.

Delivering on the promise of food innovation requires mechanisms to reduce barriers. This paper presents a framework to **source** innovations, **shape** them to be fit for purpose and **scale** them by mobilizing the right ecosystem of partners to drive adoption. To illustrate how the framework can be realized, it draws on the initiatives of the World Economic Forum's Food Innovation Hubs, as well as on two of its focus topics: advancing soil health and protein innovation.

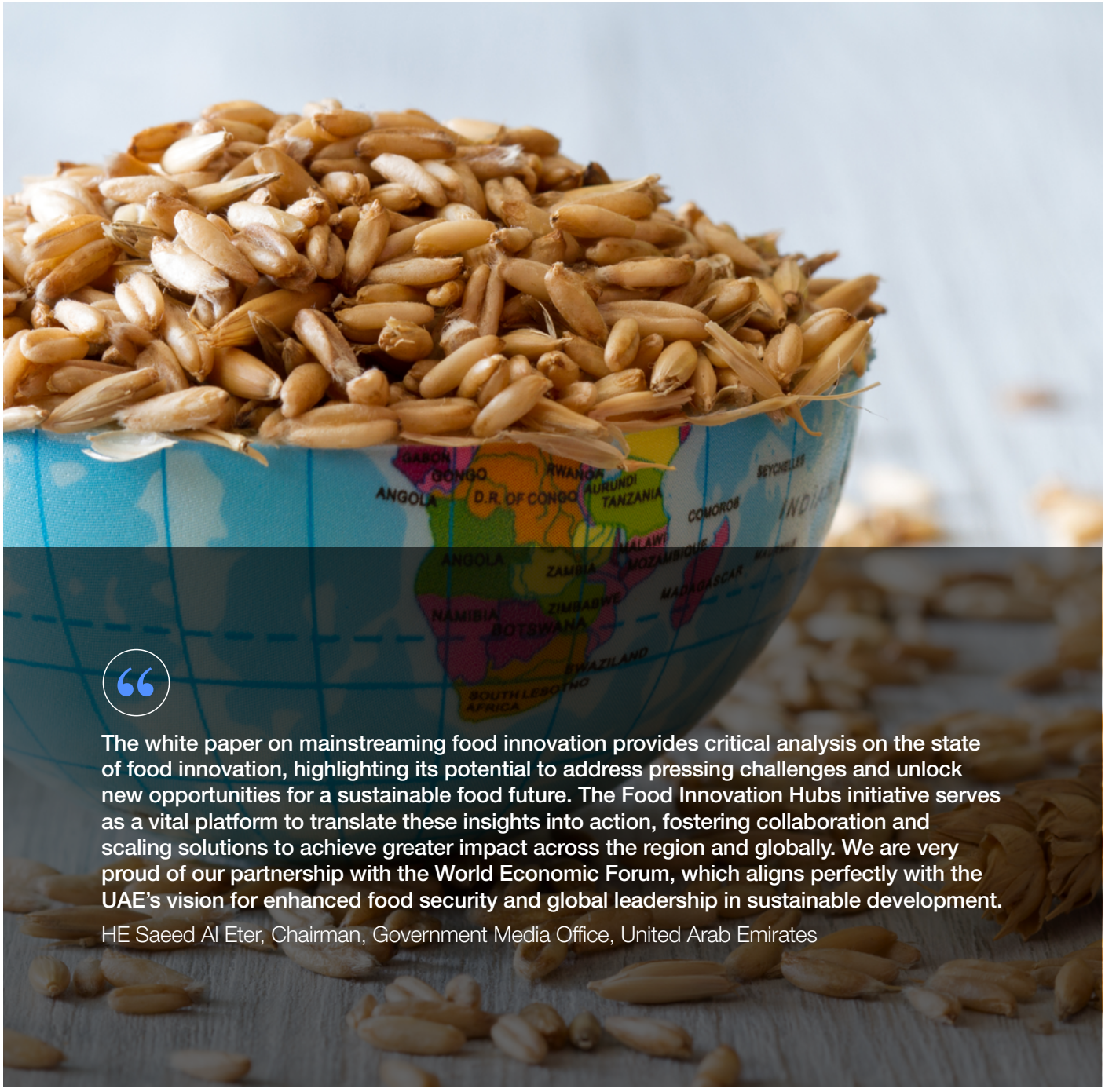
Every stakeholder has a role to play in unleashing the potential of transforming food systems. The private sector is called on to invest in research and development (R&D), make direct investments, derisk adoption and deploy market expertise to co-create and collaborate. Governments can foster collaborations, provide incentives and support public research. Non-governmental organizations (NGOs) and civil society bodies can act as intermediaries and facilitate collaboration, uptake and integration. Farmers can invest in, as well as help co-design and test, new technologies and share their knowledge. Innovators can engage with stakeholders throughout the value chain to build adaptable solutions and seek high-potential funding and partnerships to scale their technologies. Financial institutions, including philanthropies, investors, development financing bodies and others, can play a crucial role by adopting a long-term perspective and sourcing innovations with high scalability and sustainability potential.

Addressing the challenges facing global food systems requires urgent action and collaboration. By unifying efforts to source, shape and scale innovations, a coalition of aligned partners can create ecosystems that derisk investments and uptake by stakeholders through regulatory support, secured offtake and increased adoption of food innovations.

> **As a food and beverage company that relies on agriculture, we know that the world urgently needs more resilient food systems. We can't afford to keep talking about change – we need to act now. And that's what this report is all about: how we can work together to support change and innovation on the ground, in partnership with farmers and communities. This is critical reading for anyone who wants to learn more about how we can scale innovations that build resilience in our food systems – from the latest soil health technologies to ways we can better share information between stakeholders – and enable a stronger, more sustainable future for us all.**
>
> Ramon Laguarta, Chairman and Chief Executive Officer, PepsiCo

1 Tackling food system challenges: Innovation offers a solution

While technology and innovations promise to address challenges in food systems, they are not achieving their full potential and impact.



> The white paper on mainstreaming food innovation provides critical analysis on the state of food innovation, highlighting its potential to address pressing challenges and unlock new opportunities for a sustainable food future. The Food Innovation Hubs initiative serves as a vital platform to translate these insights into action, fostering collaboration and scaling solutions to achieve greater impact across the region and globally. We are very proud of our partnership with the World Economic Forum, which aligns perfectly with the UAE's vision for enhanced food security and global leadership in sustainable development.
>
> HE Saeed Al Eter, Chairman, Government Media Office, United Arab Emirates

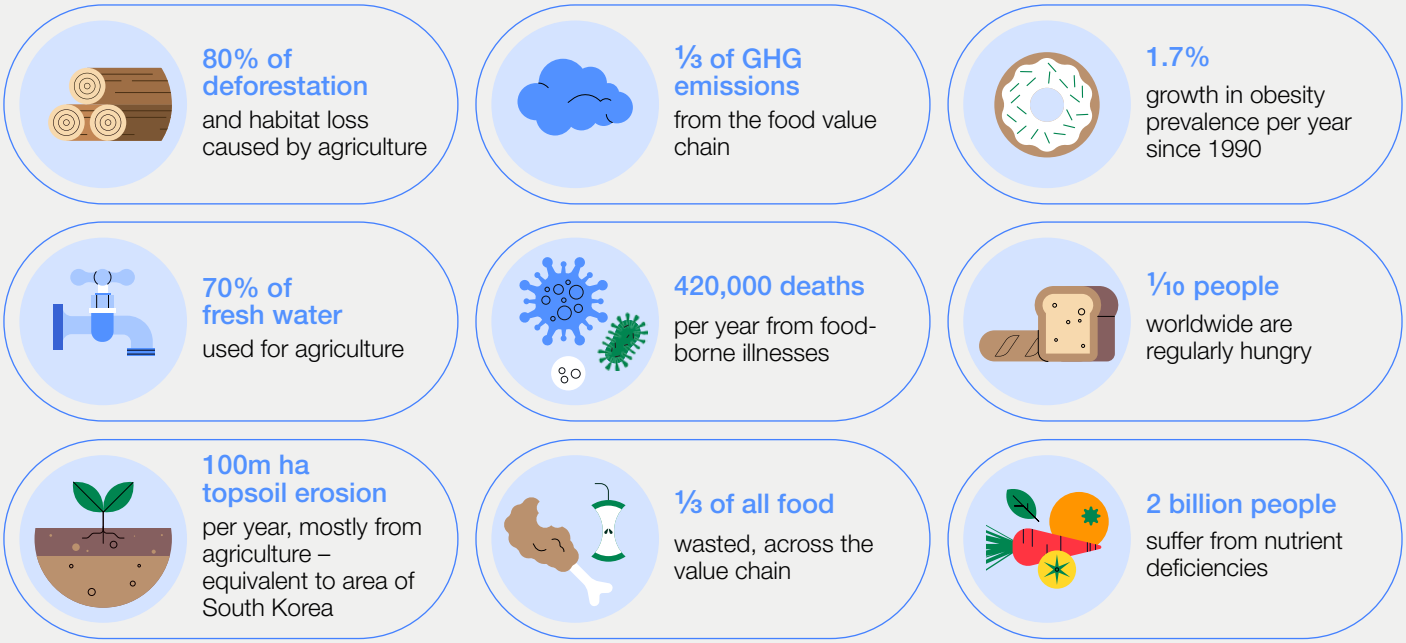
Innovation is urgently needed to address complex problems facing global food systems, as it has the power to substantially mitigate their environmental impact. But despite a healthy amount of early-stage food innovation, scaling remains an ongoing challenge. Sector-specific barriers including unfavourable unit economics and regulations, fragmented market systems, limited opportunities to co-develop solutions and inconsistent consumer demand inhibit the adoption of innovations.

1.1 The world's food systems are struggling

Global food systems today are contending with a dwindling supply of arable land while attempting to feed a growing global population. With current trends, over 90% of global soils could be degraded by 2050, reducing world food production by 10%.[2] Farmers, the foundation of the food system, bear the full brunt of its dysfunction: of the 700 million people living in extreme poverty globally, about two-thirds work in agriculture.[3]

Nevertheless, the food system will need to produce more calories in 2030 vs. 2020, since the world population and per capita calorie consumption are growing at 0.86% and 0.39% per year, respectively.[4] Compounding this increased demand, consumption is becoming more resource-intensive and waste is increasing (Figure 1).[5] Immediate change is needed to improve this situation and prevent it from worsening.

FIGURE 1 **Challenges for the world's food systems**



Source: United Nations Convention to Combat Desertification (UNCDD), Nature Food, World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), British Broadcasting Corporation (BBC)[6]

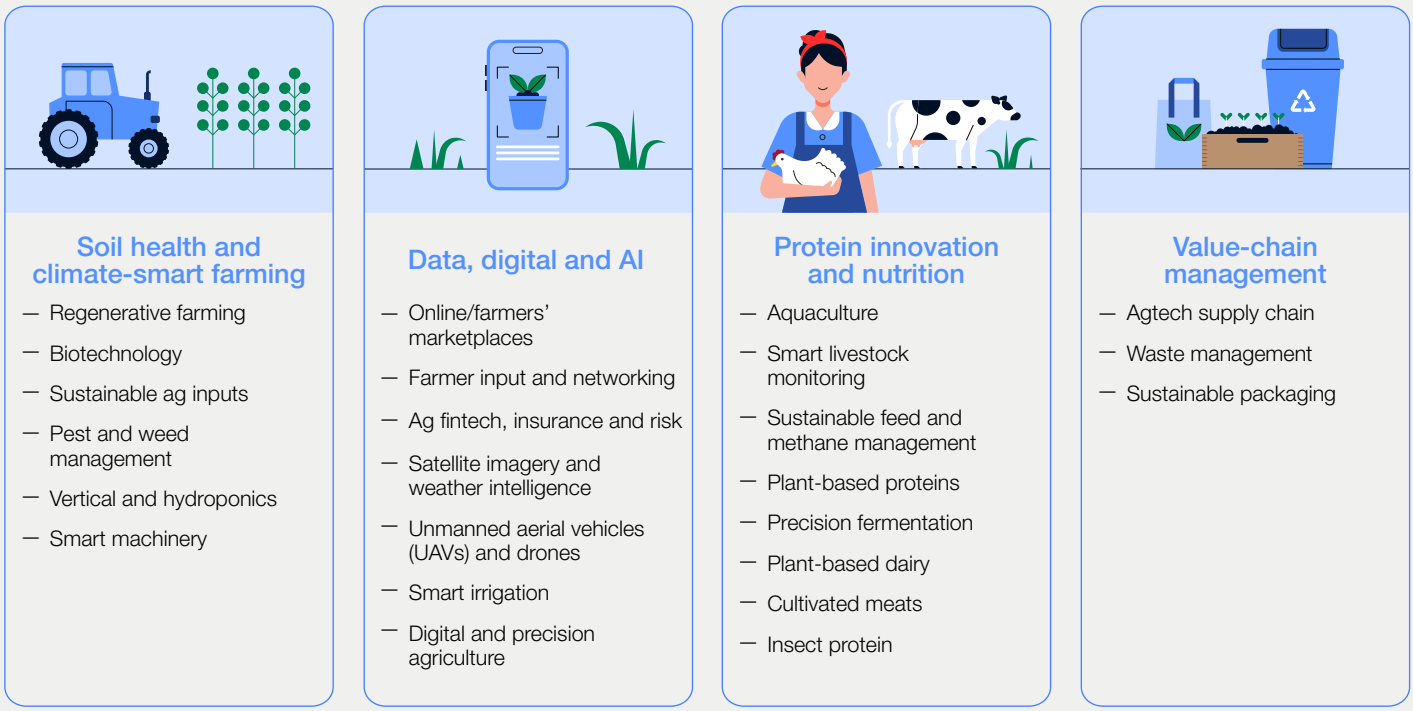
> **As it applies to all economic sectors, food systems must increase their sustainability levels through innovation. Farmers lie at the centre of food systems and therefore innovation can only be farmer-centric – which does not mean that farmers must implement innovative methods conceived by other entities. It means that farmers should be co-designers, co-creators and co-implementers of that innovation. Moreover, if available investments on innovation are drained on real agricultural production, food systems will become compliant with the 'one health approach'.**
>
> Arnold Puech d'Alissac, President, World Farmers' Organisation

1.2 Innovations in food systems can offer a solution

Technical innovations are being developed to tackle key points in food systems – from upstream innovations in agricultural practices to midstream innovations in processing, logistics and distribution, and downstream innovations in consumption and disposal. In addition, interactions across the system are being transformed – in marketplaces, but also in policy, business models and collaboration between different actors.

The following section presents and analyses four innovation areas, based on the observed landscape of venture capital and patenting activity (Figure 2).[7]

FIGURE 2 **Overview of major food innovation areas**



Source: Pitchbook, Boston Consulting Group (BCG) analysis

BOX 1 **Food innovations detailed**

Soil health and climate-smart farming involve improving agricultural productivity and sustainability through regenerative and sustainable practices, as well as advanced technologies.

- **Regenerative farming:** Various agricultural practices such as minimizing tilling, cover crops, intercropping, planting perennial plants, diversifying species to restore soil health, minimizing chemical inputs, improving water management, increasing soil organic carbon and providing other ecosystem benefits.
- **Biotechnology:** Innovations to create crops with improved traits such as pest resistance, drought tolerance and superior nutritional content.
- **Sustainable agricultural chemicals:** Innovations in inputs to minimize their environmental impacts, while ensuring productivity, such as biofertilizers.
- **Pest and weed management:** Alternative pest-management and biological-control methods to reduce the need for chemical pesticides.
- **Vertical and hydroponics:** Controlled-environment crop production systems to maximize resource and space efficiency.
- **Smart machinery:** Machinery to support the performance of farm tasks with high precision and efficiency, increasingly using artificial intelligence (AI) and robotics.
- **Smart irrigation:** Technologies using real-time data to optimize water use and improve soil health.

Protein innovation and nutrition improves the sustainability of conventional proteins and develops alternative sources.

- **Aquaculture:** Innovative methods of farming fish, mussels and seaweed in controlled environments.
- **Smart livestock monitoring:** Technologies that monitor and improve livestock health and productivity through sensors and data analytics.
- **Sustainable feed and methane management:** Techniques and technologies to reduce and capture methane emissions from livestock.
- **Plant-based proteins:** Derived from sources such as soy, peas and a range of emergent crops, used to develop alternatives to meat.[8]
- **Precision fermentation:** A process using microbial fermentation to produce specific proteins and other ingredients conventionally sourced from animals.
- **Plant-based dairy:** Dairy alternatives made from plants, including those produced to cater for special dietary needs.
- **Cultivated meats:** Meats produced by culturing animal cells, offering potentially more sustainable and ethical alternatives to traditional meat.
- **Insect protein:** High-protein, low-impact food source farmed sustainably and processed into protein-rich foods for human consumption.

Value-chain management improves the efficiency, transparency and sustainability of the agricultural supply chain.

- **Agtech supply chain:** Tools to improve logistics, reduce losses and ensure traceability from production to consumption, as well as distribution of risk and value, including new technologies for food storage and blockchain applications.
- **Waste management:** Aerobic/anaerobic digesters to manage farm waste and produce methane.
- **Sustainable packaging:** Coatings and technologies to increase the shelf life of agricultural produce.

Data/digital uses advanced technologies to gather and analyse data, optimizing farming practices and improving market access.

- **Online/farmers' marketplaces:** Platforms and data on product demand to connect farmers with each other and with experts, facilitating knowledge- and resource-sharing.
- **Ag fintech, insurance and risk:** Financial technologies tailored to agriculture, including digital payment systems, credit scoring and insurance products.
- **Satellite imagery and weather intelligence:** Systems to capture images of the Earth's surface and predict weather conditions to help farmers optimize farming activities.
- **Unmanned aerial vehicles (UAVs)/drones:** Used for aerial imaging and collection of data on crop health, irrigation and land conditions.
- **Smart irrigation:** Technologies to optimize water use based on real-time data, reducing waste and improving crop health, particularly in water-scarce regions.
- **Digital and precision agriculture:** Tools to optimize agricultural inputs such as water, fertilizers and pesticides through the internet of things (IoT), AI and data analytics.

Food innovations can have substantial positive impacts. To give a few examples, smart irrigation can save up to 50% of water compared with conventional irrigation.[9] Inhibited and biostimulant-enriched fertilizers can reduce the fertilizers' greenhouse gas (GHG) emissions by 30–40% while increasing productivity by 10%.[10] Plant-based alternatives for animal proteins could cut more than 1 gigatonne of CO_2e emissions and save 39 billion cubic metres of water.[11] As an example of the potential of digital tools in agriculture, an AI-powered platform for soil-health monitoring was able to reduce water usage by 57% and fertilizer usage by 15%, and increase yields by 70%.[12]

1.3 Early-stage food innovations are strong, but scaling is a challenge

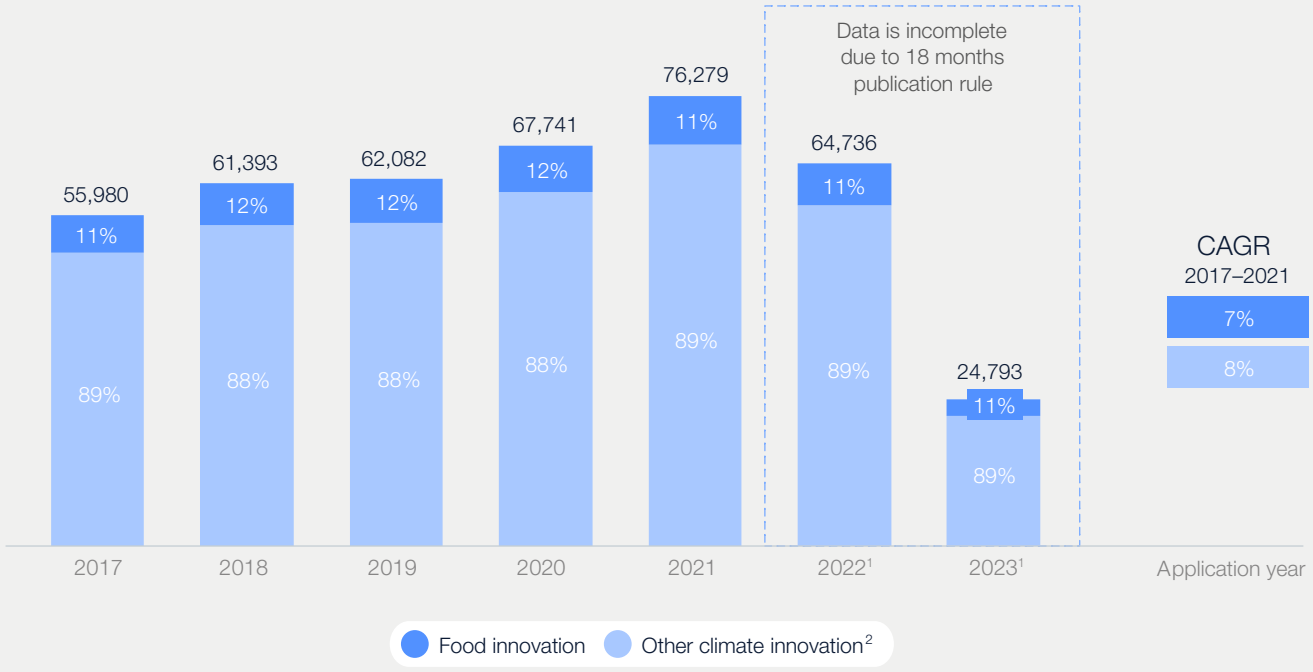
Investment trends suggest that innovation is not scaling at the same rate as climate innovation more broadly, which includes a range of technologies associated with the energy transition and sustainability.[13]

Presented here are key indicators of the overall health of food innovation, focusing on start-ups and innovators to provide clarity on the innovation landscape and its potential. While the venture capital and patenting trends do not cover the entire ecosystem (the systemic transition that includes not only financial investment but also collaboration among various stakeholders, policy support and consumer education/information), they serve as a useful point of focus to shed light on larger trends in food innovation.

Although patenting activity indicates that food innovation is occurring, exit sizes, overall investments and growth rates remain small, as measured by venture-capital investments. This limits the impact of food innovation, highlighting the need for mechanisms to facilitate scale.

- **Patenting:** Patenting activity in food innovation is growing at 7.1%, only slightly slower than climate innovation overall, indicating that food innovation is occurring in line with general climate innovation trends (Figure 3).
- **Exits:** In food innovation, exits are significantly smaller than the average in climate innovation – 20% lower on mergers and acquisitions (M&As) and 40% lower on initial public offerings (IPOs).[14]
- **Late-stage investment:** Food innovation is among the lowest in terms of late-stage investment across climate innovation (40% lower than average).[15] Late-stage investment is crucial to ensure scale; lack of this stage of investment could explain the smaller exit sizes.
- **Overall investment:** Since 2021, investments in climate innovation have been decreasing; but investments in food innovation have retreated faster. Whereas in 2020, food innovation accounted for almost a quarter of climate-tech investment, it is now only 8%, and falling (Figure 4). Segmenting the types of food innovation, investment in most areas of food innovation have been falling from their 2021 peak (Figure 5). Soil health and climate-smart farming have received the most investment and contain the greatest number of start-ups.

FIGURE 3 | **Food innovation patenting activity has grown in line with climate innovation overall**

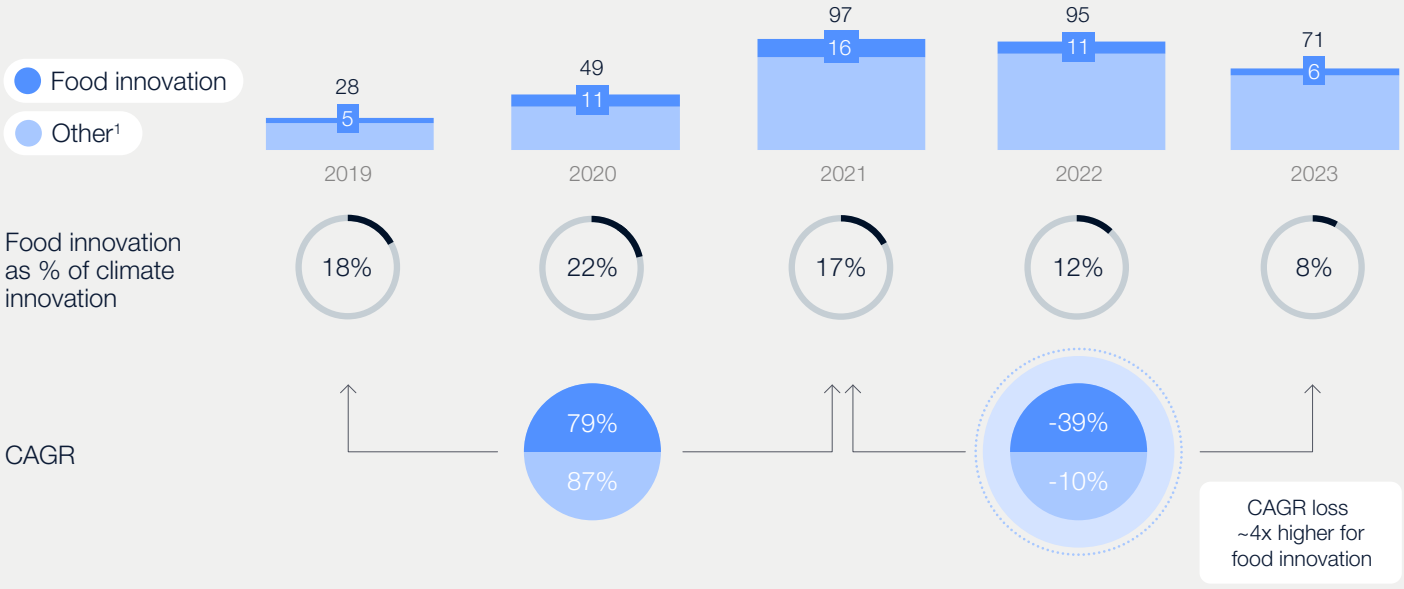


Notes: 1. Patents data for 2022/2023 might be incomplete due to the 18 months publication rule. 2. "Other" category includes: nature preservation, offsetting and compensation, carbon capture, utilization and storage (CCUS), efficiency, fuel and material switch, demand management., power generation, electrified solution. Analysis based on climate-related patents filed since 2017, identified using a combination of keyword-based strategies and patent tech codes.

Source: Patentsight, Derwent Innovation, Boston Consulting Group (BCG) Center of Growth and Innovation Analytics, BCG Green Tech Portal, BCG analysis

FIGURE 4 | **Investments in food innovation are falling behind**

Investment in food innovation vs. climate innovation (in $ billions, 2019–2023)

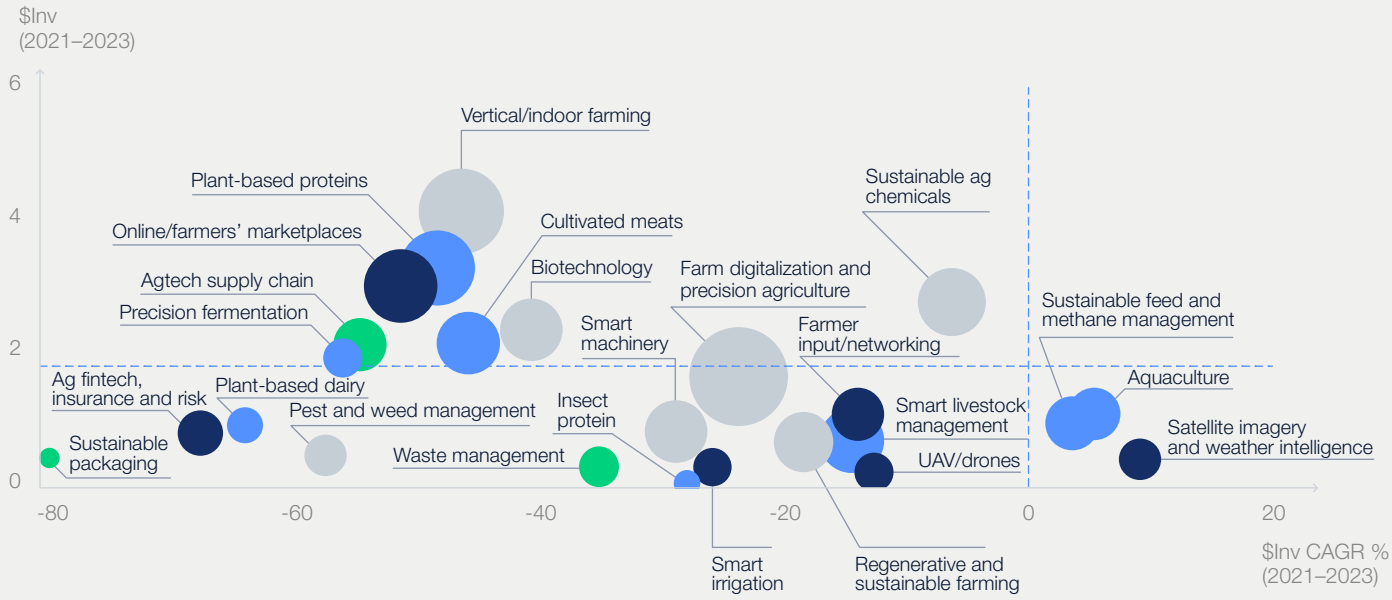


Notes: 1. "Other" category includes: nature preservation, offsetting and compensation, carbon capture, utilization and storage (CCUS), efficiency, fuel and material switch, demand management, power generation, electrified solution. Analysis based on equity deals. Does not include mergers and acquisitions (M&A), initial public offerings (IPO), debt or corporate financing programmes.

Source: BCG Greentech Portal, Pitchbook, Center for Growth & Innovation Analytics, BCG analysis

FIGURE 5 | **Most food innovation experienced negative growth in 2021–2023**

Investment in food innovation technologies (in $ billions)



Bubble size indicates number of companies that received investment = 50

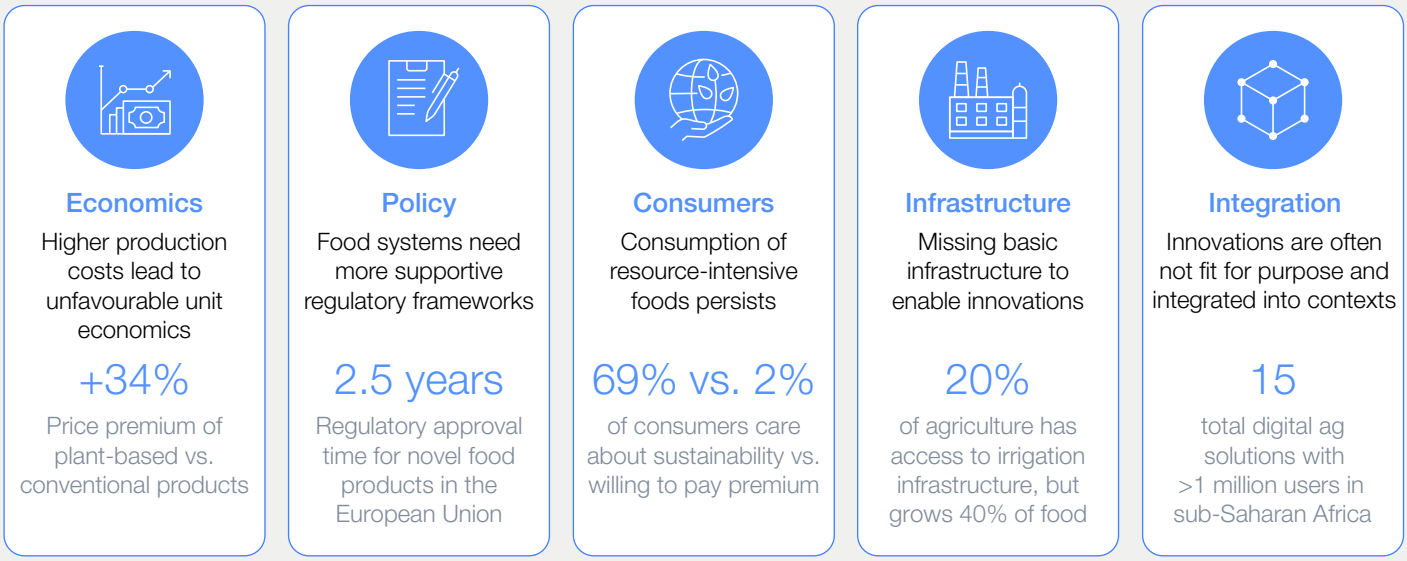
Soil health and climate-smart farming | Protein innovation and nutrition | Value-chain management | Data/digital

Source: BCG Green Tech Portal, Pitchbook, BCG Center for Growth and Innovation Analytics, BCG analysis

1.4 Barriers to mainstreaming and scaling food innovation

The five barriers in Figure 6 may help explain the lack of scale. However, the lack of collaboration in food innovation is further preventing large-scale applicability.

FIGURE 6 **Barriers that inhibit scaling of innovations**



Source: Protein Production Technology, PwC, Statista, FAO, Good Food Institute

Economics: Transition and unit economics
Food innovation investments often have longer return on investment (ROI) periods compared to other climate innovation sectors. For example, transitioning to regenerative agriculture requires investment in new machinery and can initially reduce yields by up to 60%. Over a decade, however, it can increase ROI by 15–25%.[16] But since many growers operate on small margins, introducing new practices and technologies is not always feasible.[17] Often, they are missing access to affordable inputs. Overall, food innovations suffer from unfavourable unit economics (high production costs per unit) and financial innovation is needed for systemic uptake, including derisk mechanisms, patient capital[18] and insurance options.

Policy: Complex landscapes
Government policies and subsidies are complex as well as region-specific. For example, approving novel food products in the European Union (EU) can take up to five years, with an average of two and a half years, discouraging new applications.[19] Agriculture policy is often unpredictable, with multiple players lobbying to shape it to their advantage, leading to unpredictability.[20] On a global level, food systems have only recently gained political momentum, including through countries prioritizing national food system strategies. In 2023, 134 countries signed up to the COP28 declaration on agriculture, food systems and climate action.[21] Finally, regulation is also needed to incentivize the adoption of innovation by farmers and producers as well as on the retailer and consumer side.

Consumers: Say–do gap
Local and cultural barriers prevent consumers from more readily embracing food innovations. For example, there is an ongoing mismatch between consumer preference and consumer behaviour. According to a consumer survey by the Boston Consulting Group (BCG), 69% of consumers express concern about sustainability in food categories, but only 7% translate this concern into action by purchasing sustainable products – a substantial gap between awareness and purchasing behaviour – and a mere 2% are willing to pay a premium for sustainably produced food.[22]

Infrastructure: Lacking foundations
Insufficient infrastructure is a serious problem, especially for technological scaling. Irrigated agriculture, covering only 20% of cultivated land, contributes to 40% of the world's total food production. This highlights the critical role of adequate infrastructure in enhancing productivity – including a shared backbone of infrastructure, both socioeconomic and otherwise, such as education, health and social amenities, roads, railways, electricity/energy, water and broadband.[23] Access to the latter has been shown to have positive impacts on the development of the agriculture sector, thereby providing the basis for innovations and advanced technologies.[24]

Integration: Tailoring to specific contexts
A frequent challenge in food innovation is that solutions address specific problems but do not provide integrated systems that can be applied successfully in a given context. Indicative of this challenge, in sub-Saharan Africa, only 15 digital agriculture solutions have exceeded 1 million registered users, and of those, only 15–30% are active users, partially due to insufficient integration with broader agricultural systems.[25] Coupled with the proliferation of solutions, the lack of co-creation creates an imbalance, a lack of understanding of the available solutions and potential mistrust.

While innovation has the potential to address pressing challenges in food systems, realizing its full potential requires more than just technological advances. The following section investigates innovation ecosystems and how they can be harnessed to support mainstreaming of food innovation, outlining a framework and illustrating it with the Food Innovation Hubs, which foster collaboration and investment and create catalytic environments for innovation, including in policy and business models, with the potential for greater impact.

2 Unlocking adoption and scale through innovation ecosystems

Innovation must be systematically sourced, shaped and scaled with the support of multistakeholder ecosystems.

> **We need innovation in all parts of African and global food systems in order to achieve our collective sustainable development goals – for people, planet and our shared prosperity. The Food Innovation Hubs model is one that can be tailored to unique African contexts, bringing together the most relevant and cutting-edge food systems solutions, a conducive enabling environment, and an inclusive ecosystem of partners and local expertise to lead the way in creating a more equitable and sustainable future for all. This presents an immense opportunity for Africa, particularly the young innovators and public- and private-sector leaders shaping its future.**
>
> Agnes Kalibata, President of AGRA

2.1 Food innovation ecosystems

To harness the potential of emerging technologies and innovation in food systems, a coordinated approach is needed. Innovation ecosystems can support the fluid integration and needs of all stakeholders involved, leading to emergent benefits.

Examples:

- The Netherlands is renowned for its collaborative ecosystem, incorporating Wageningen University & Research and other research institutions, local government, EU institutions such as EIT Food and the private sector. Public–private partners work together to develop innovations in food and agriculture by sharing and applying the available expertise, facilities and equipment.[26]

- Singapore has positioned itself as a global leader in innovation through its unique ecosystem. Built on a foundation of government investment in R&D, it draws on both Singapore's unique position as a global trading hot spot and its skilled workforce. Food innovation (biotech, agritech, alternative proteins) has been an important focus for its deep-tech investments.[27]

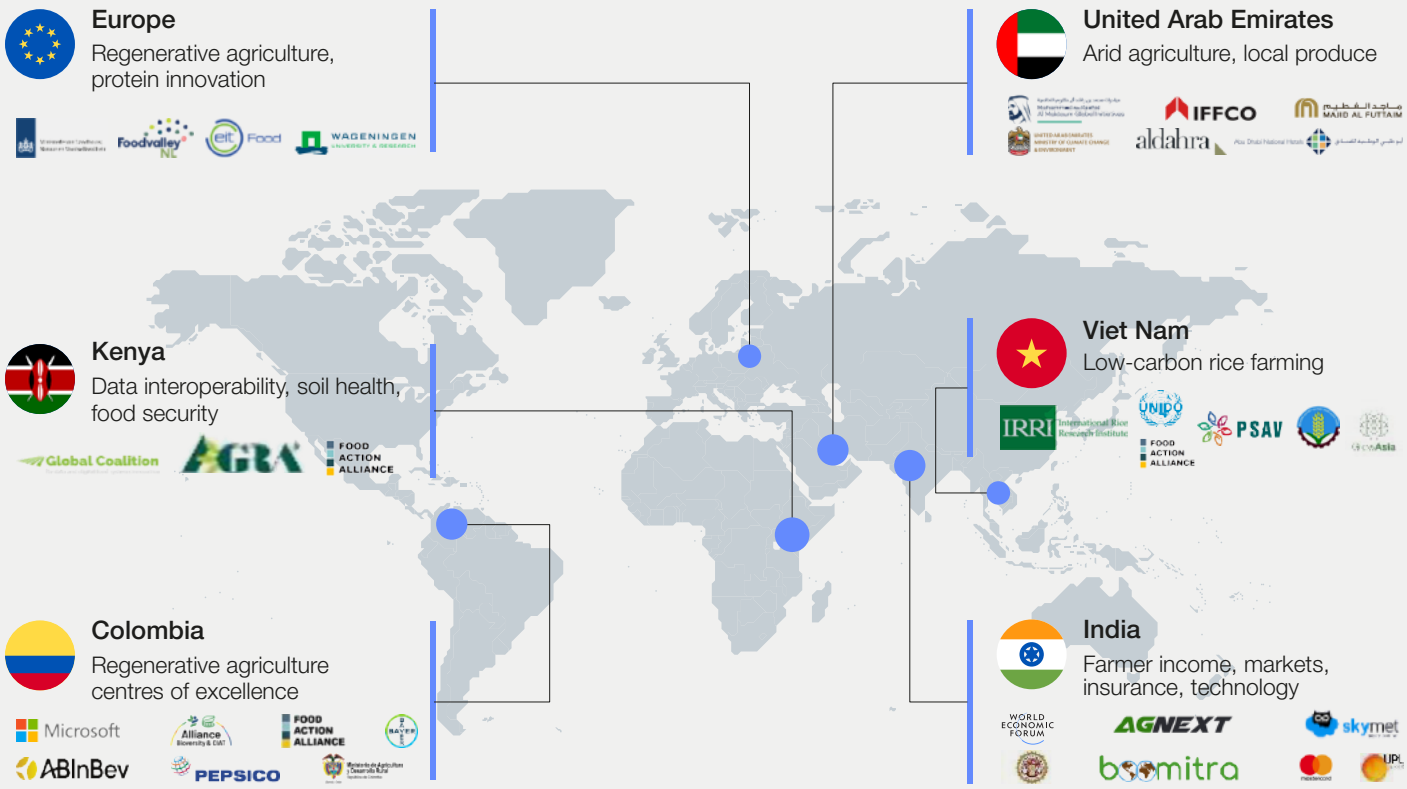
- Silicon Valley's success lies in its strong venture capital scene, its ability to attract global talent, and its robust talent pool emerging from leading universities, all working in synergy to drive continuous innovation and economic growth. Focusing on building innovative platforms in addition to products, Silicon Valley's ecosystem has been able to attract talent from around the world, offering an open and collaborative culture in which different functions can work together on specific innovation projects.[28]

To unlock food innovation's potential and given the imperative for impact, a mechanism is needed that co-designs, develops, customizes and encourages the adoption of innovative methods. Recognizing this need, the World Economic Forum's Food Innovation Hubs bring together partners from the private sector, civil society, governments, financial institutions and innovators to strengthen the food innovation ecosystem.

- The Forum's country and regional Food Innovation Hubs build multistakeholder partnerships and provide a framework for cooperation to drive adoption of innovations and make them fit for purpose. Six pacesetter hubs are under development in Colombia, Europe, India, Africa, the United Arab Emirates and Viet Nam (Figure 7). Case studies from these hubs follow in the next section.

- To enable global knowledge exchange and collaboration, the Food Innovators Network connects the hubs through a curated community of innovators and practitioners. The network organizes learning sprints on global frontier innovations – areas of food innovation suffering from underinvestment or requiring a coordinated approach to achieve scale. Detailed investigations of two such areas – soil health and protein innovation – follow in the next section.

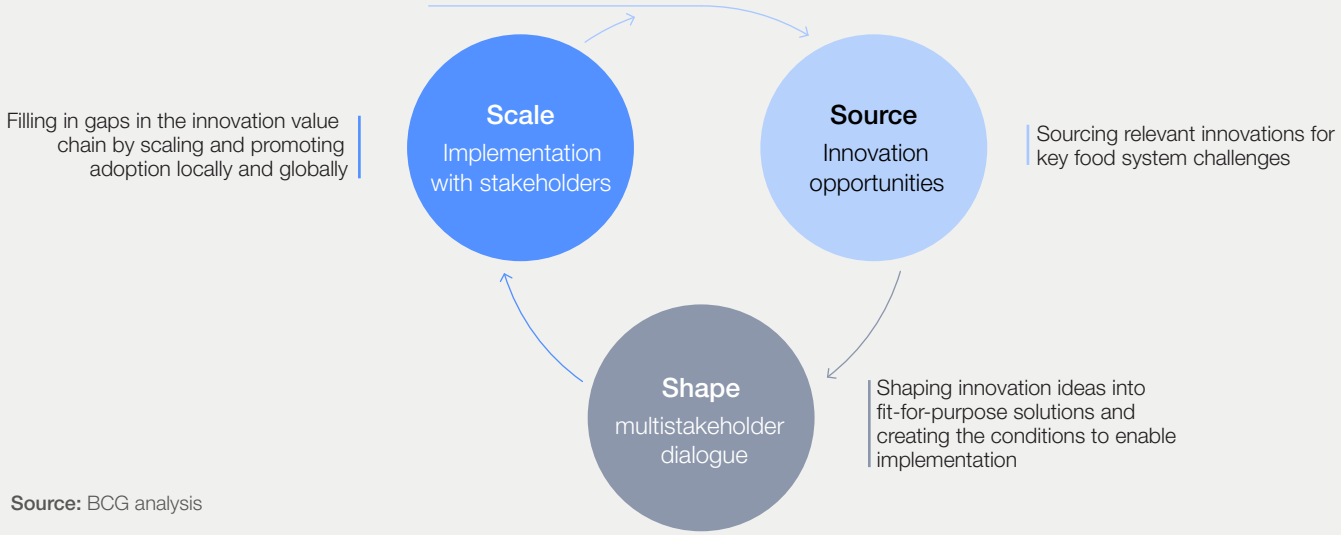
FIGURE 7 | **Food Innovation Hubs under development**



Source: Food Innovation Hubs Global Initiative, BCG analysis

2.2 A framework for ecosystem cooperation: Source, shape, scale

FIGURE 8 | **Source–shape–scale framework**



Source: BCG analysis

Source: Identifying relevant innovations for key food system challenges

Innovation needs are identified and sourced through landscape analyses, innovation challenges and stakeholder consultations. Sources of innovations include universities, start-up networks, incubators and accelerators, farmer organizations, cooperatives, open innovation platforms and industry experts.

Crowdsourcing innovations: The Food Innovation Hub India, in collaboration with the government of Madhya Pradesh, and with catalytic support from the Bill & Melinda Gates Foundation, conducted a landscape analysis to identify a framework for innovation opportunities. Organizations with existing technology solutions were invited to submit proposals in line with the state's agriculture development priorities. In total, the innovation projects submitted (partnerships with the private sector, government, civil society and technology providers) promised to unlock $1.6 billion in value for food systems. Currently, seven projects are active, creating impacts across a range of areas from crop diversification to insurance and digitalization. The hub plays the key role of neutral broker for the partnerships. Through the hub mechanism, there is potential for private-sector participants to transition their engagement from corporate social responsibility initiatives to longer-term investments where this aligns with longer-term priorities for the core business.

Launching challenges to source innovations: Food Innovation Hubs have purposefully sought out innovations in specific topic areas. These have had ripple effects across the ecosystem that have driven additional adjacent innovations.

- The Food Innovation Hub Europe has designed a challenge on "personalized nutrition for all" to find innovative solutions to reduce obesity and malnutrition across Europe. Nine innovations have received financing, monitoring, network access and visibility and have since become successful.[29]

- In the United Arab Emirates, one of the barriers to scale is the lack of relevant solutions and testing grounds for innovators. The UAE hub is using the World Economic Forum's UpLink platform to run an innovation challenge with the ambition of identifying and testing best-in-class innovators to boost arid climate production in the UAE.[30]

By sourcing solutions to solve local challenges, partners have congregated organically around the hubs. These innovation challenges were crucial for the establishment of the respective hubs, which have become long-term ecosystems that have generated follow-on innovations.

BOX 2 **Making use of the UpLink open innovation platform to source food innovations**

UpLink, the World Economic Forum's early-stage innovation platform, aims to unlock an entrepreneurial revolution to accelerate positive change for people and planet. Through an innovation challenge framework, the platform discovers high-quality, high-potential and scalable innovative solutions. To date, the platform has run two food innovation challenges with previous funding partners on the topics of food ecosystems in arid climates and climate-smart agriculture. Through these challenges it has selected 22 top innovators who, as well as acquiring increased visibility, gain access to the partners and funding needed to scale.[31]

Shape: Understanding challenges and opportunities through multistakeholder dialogue and action

Often, innovations are available but they need to be adapted to specific contexts. Customizing these solutions and refining their market fit require robust partnership frameworks, continuous development of the solutions and, in most cases, co-creation with farmers. Diverse stakeholder consultations and incubations as well as user/customer feedback and strong governance models are needed to develop projects that maximize their investment potential. Combining dialogue with actionable steps ensures effective narratives and practical adoption pathways for food innovations.

Several Food Innovation Hubs have focused attention on this stage to ensure that the innovations are fit for purpose. Examples include the following:

Aligning with national food systems strategies: The Food Innovation Hub Viet Nam was set up by the Ministry of Agriculture and Rural Development (MARD) in support of its national action plan on food systems. This is an example of a hub succeeding in building a growth environment for a project by focusing a range of diverse contributors on a single goal.

The hub, also supported by Grow Asia, initially aims to develop 1 million hectares of high-quality and low-carbon rice, improving farmers' income while reducing GHG emissions – which it intends to achieve by scaling a range of fit-for-purpose innovations sourced from an innovation challenge. It has built a cross-sector and cross-ministerial steering committee, led by MARD, consisting of portfolios across environment, industry, trade, planning and investment, and finance, as well as international organizations, policy experts and technical experts. It also uses existing initiatives and mechanisms including the Partnership for Sustainable Agriculture in Viet Nam's rice working group, the World Bank's low-carbon rice programmes and others. By aligning efforts, the solutions sourced through the innovation challenge will benefit from a robust and targeted enabling environment, which will allow deployment at scale.

Developing a coalition of the willing: The Europe Hub's Regenerative Innovation Portfolio is establishing a coalition of regional partners to scale across Europe. Initially launched as a fund, the portfolio has evolved into a comprehensive initiative, unlocking new partnerships between food systems to generate viable business models for farmers transitioning to regenerative practices. It has the following three solution areas:

- Matching supply and demand by working with offtakers to secure a market for new crops before transitioning farmers to these methods
- Valuing ecosystem services – including holistic benefits beyond carbon pricing, such as biodiversity, water retention and improved soil health – by developing ways to integrate these services into the value of produce through practices such as mixed cropping
- Derisking farmers by providing financial incentives, insurance solutions and collaborative support

The first pilot in Navarra, Spain, involving 1,000 farmers has been successful thanks to the pre-existing partnership of actors that the portfolio had established. Now, the portfolio has begun applying the lessons learned across Europe, contributing to a continent-wide food system transition. By facilitating collaboration at the farm level and ensuring financial and value-chain support, the Regenerative Innovation Portfolio creates a sustainable pathway for adopting and scaling regenerative agriculture across Europe.

Unlocking a shared data ecosystem: The agrifood data ecosystem in Kenya is highly fragmented, hindering effective planning and decision-making. To address this challenge, the Food Innovation Hub Kenya launched the "OneMap" initiative, the goal of which was to identify a platform providing global analytics access and advanced data analytics capacity for Kenya. Through a series of workshops with various institutions including FAO, CGIAR and the World Bank, the hub designed a shared action agenda to scale specific innovations in food systems. Workshops and interviews were conducted on two priority use cases – soil health and yield forecasting – with important stakeholders from the public and private sectors, civil society and innovators.

The resulting OneMap case requirements document maps Kenya's current data ecosystem and proposed interventions and highlights the critical role of multistakeholder engagement and a comprehensive, collaborative approach in developing effective digital agriculture solutions. However, efforts are still in the scoping phase due to lack of resources, political shifts and an overcrowded marketplace, signalling the need for robust ecosystem cooperation. The insights gained – mostly surrounding the potential of multistakeholder partnerships – offer valuable guidance for the future development of the Food Innovation Hub in Kenya.[32]

Scale: Filling in gaps in the innovation value chain by scaling and promoting adoption locally and globally

Innovations must be supported to become mainstreamed and commercially viable. This involves creating investment cases and strengthening pathways for scale, including geographic expansion and enlargement of market share. As the innovations scale, they often lead to follow-on innovations, which in turn can be shaped and scaled themselves, creating a continuous loop.

Co-investing with farmers: The Food Innovation Hub Colombia is an example of moving beyond business-as-usual. The initial coalition of the willing included farmer organizations such as Sociedad de Agricultores de Colombia that invested time and resources in building a framework for the Food Innovation Hub, with research institutions and the private sector. The main outcome was the development of an innovative approach to solving issues, ensuring profitable rural economies rather than benefitting specific value chains. Through tech-supported regenerative agriculture centres of excellence in Cundinamarca and Boyacá, the hub set up an intercropping cluster for potato and barley. While intercropping is not a new practice, the unique value-add from this hub is the collaboration model whereby:

- Microsoft is providing internet connectivity around farms to enable precision agriculture and technologies to collect and analyse farm data.
- Anheuser-Busch InBev is supplying barley crop seeds and fertilizers and providing hands-on training for farmers.
- Bayer is offering agronomy advice and recommendations for improving barley crop yields.
- PepsiCo is providing potato seeds and supporting the project's development, including unlocking engagement with several partners.
- The Centro Internacional de Agricultura Tropical (CIAT) is managing the project, analysing market opportunities and facilitating connections between farmers and buyers.
- Local civil society and farmer organizations continue to offer advice, share knowledge and implement.

Currently, an association of 120 young farmers is being organized to learn, adopt and disseminate practices and technologies. The hub now operates as a co-investment platform hosted at Alliance Bioversity International and CIAT and is expanding the model to other regions and crops in Colombia. This collaborative approach not only supports the adoption of known and validated innovations, such as intercropping and precision agriculture, but also ensures a holistic approach.[33]

Government partnerships to scale innovation: An Artificial Intelligence for Agriculture Innovation (AI4AI) initiative in India works in tandem with the Food Innovation Hub in India. Using AI and other emerging technologies for agriculture, it has demonstrated how its unique partnership frameworks under the guidance of the World Economic Forum's Centre for the Fourth Industrial Revolution (C4IR) India can enable adoption. Successes include:

- Weather-based crop advisory services: In Telangana, farmers received hyperlocal weather forecasts and advisories, reducing weather-related crop losses. Farmers reported a 20% increase in crop yield and a significant reduction in weather-related risks.
- Digitalizing support: In Telangana, AI tools were developed to assess chilli crop quality, resulting in a 15% increase in market prices for farmers.
- Voluntary carbon markets: In collaboration with local cooperatives, various carbon farming projects were implemented in Madhya Pradesh. Participating farmers saw a 10% increase in income from carbon credits.
- Crop diversification: A policy scheme on crop diversification is being developed by the government of Madhya Pradesh, which will help farmers diversify towards sugar-cane farming, with assured buyback from sugar mills, increased ethanol production and reduced usage of electricity. When implemented, the project aims to save more than 15 million litres of water through reduced irrigation.

Due to these successes, the public-private partnership frameworks developed in Madhya Pradesh and Telangana are being expanded to other states in the country. They are driving adoption of agritech solutions at scale by improving market access, farmer incomes and sustainability.

Way forward

To successfully scale food innovations, a systemic approach is needed – involving a broad community of stakeholders encompassing the entire food value chain. Given the fragmented nature of food systems, some innovations may not be able to develop commercialization pathways or may experience long incubation periods.

At their core, **the Food Innovation Hubs are cooperation mechanisms** that can reduce fragmentation, distribute risk and promote equity. As food innovation ecosystems, these hubs are tailored to a country's/region's needs and offer a pathway for a range of participants to innovate and collaborate successfully.

Food Innovation Hubs playbook

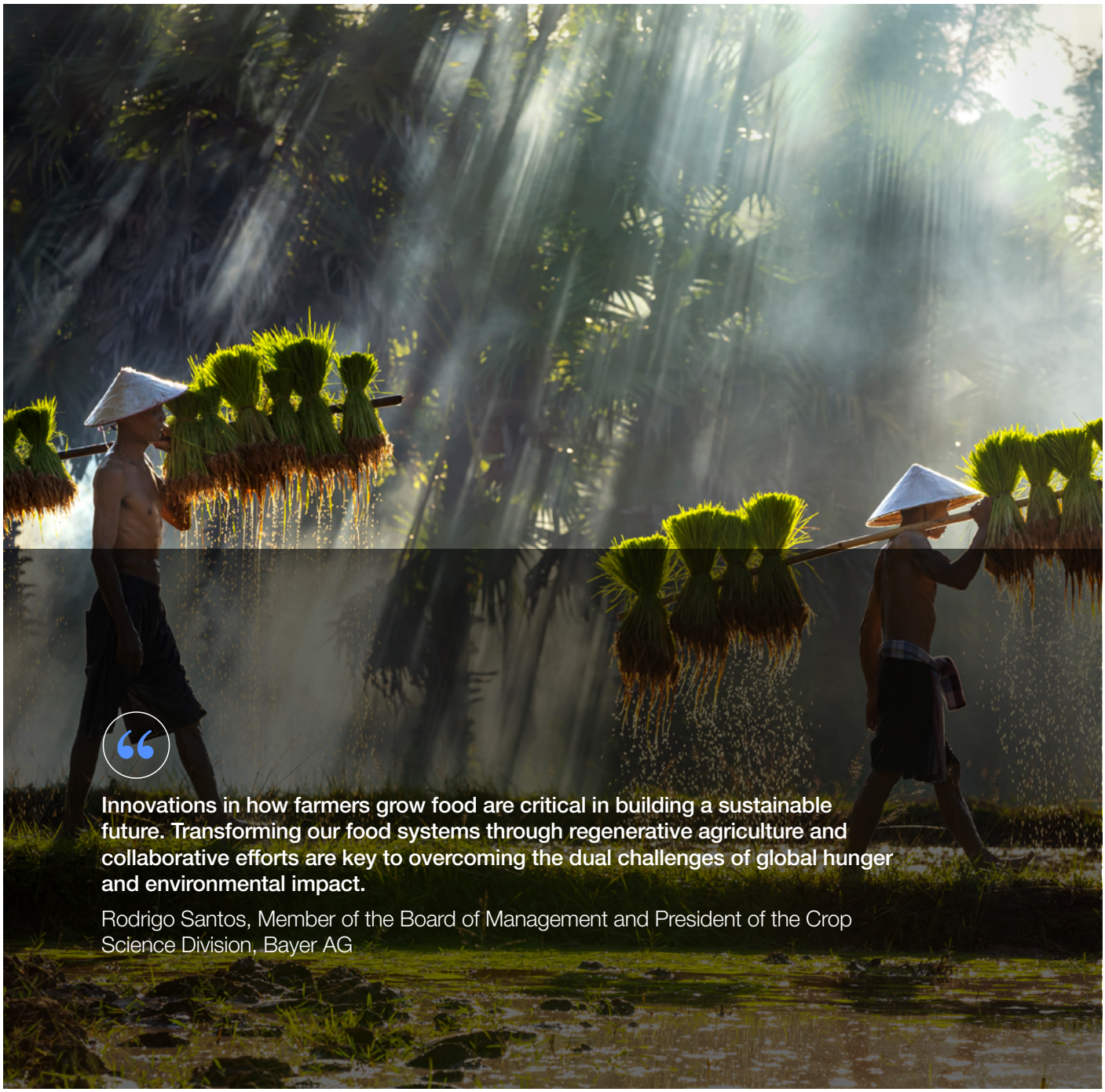
A playbook has been developed to establish and accelerate Food Innovation Hubs.[34] It serves as a comprehensive guide to setting up new, or managing and developing existing, regional and country-specific hubs. With step-by-step information, the playbook provides a structured approach to understanding the hub's particular environment, context and opportunities, as well as to building strategies to connect the food innovation ecosystems.

> **The Food Innovation Hubs exemplify two vital enablers of change: innovation and partnership. I encourage all stakeholders in the food systems value chain to consult the playbook for best practices on designing and implementing a food innovation hub. Let us all be bold as we collectively address one of the most fundamental needs on our planet – equitable access to nutritious food.**
>
> Rania Dagash-Kamara, Assistant Executive Director for Partnerships and Innovation, United Nations World Food Programme

3

Advancing global frontiers in food innovation

Some areas of food innovation have significant impact potential, but may lack both visibility and scaling pathways, preventing them from becoming mainstream.



Innovations in how farmers grow food are critical in building a sustainable future. Transforming our food systems through regenerative agriculture and collaborative efforts are key to overcoming the dual challenges of global hunger and environmental impact.

Rodrigo Santos, Member of the Board of Management and President of the Crop Science Division, Bayer AG

As the trends outlined in the previous sections suggest, large areas of food innovation fail to become mainstream because they lack both visibility and scaling pathways. These areas require strategic foresight and collective learning to develop applications that can then be customized to local contexts. The Food Innovators Network, as a convenor of practitioners in food innovation, has been developing knowledge of such topics through learning sprints. The two areas of focus are:

– Technologies and practices for soil health (developed in collaboration with NTT Data)

– Protein innovation

3.1 Technologies and practices for soil health

This section was developed in collaboration with NTT Data.

Introduction: The importance of soil health

About 95% of the Earth's food supply relies on healthy soils, yet nearly a third of agricultural land globally is degraded.[35] Erosion removes 1% of the world's arable land per year.[36] If current trends continue, 90% of global soils will be degraded by 2050. As a result, world food production could fall by 10% on average and by up to 50% in some areas.[37] The need to secure soil health cannot be therefore understated, as it brings several co-benefits including biodiversity restoration and water cycle improvement, and the transformation of food systems into a carbon sink, while securing food for all.

Data solutions and digital technologies play a central role in this transformative process, contributing to soil health. With several participants developing new digital solutions, there is a proliferation of data points and a lack of agency and fragmentation. This calls for collaborative frameworks that enable players to build on each other's work and develop context-specific solutions that consider the innovator, markets and the farmer sides, eventually leading to an active ecosystem that promotes knowledge exchange.[38] The soil health tools and collaborative frameworks as they exist in Africa are surveyed below – building on the work of the Food Innovators Network working group on soil health.

Source: The range of soil health technologies

Both low-tech and high-tech solutions must be combined for optimal soil management. Low-tech technologies (or practices) are more accessible and cost-effective for smallholder farmers, while high-tech solutions require significant investment, but offer greater precision and accuracy.

Examples of low-tech technologies are those commonly associated with regenerative agriculture, such as minimal or no tillage, use of organic farming practices, including adding compost to increase fertility, crop rotation to prevent soil depletion, cover-cropping to reduce erosion, soil-testing using water bottles and mulching to regulate soil temperature and moisture while improving soil fertility.[39]

High-tech solutions include the use of GPS and GIS for precise mapping and monitoring of soils.[40] Depending on crop and soil requirements, these techniques allow for variable rate technology that optimizes fertilizer application.[41] Equipment such as drones offers capabilities for remote sensing and monitoring of soil indicators including moisture and temperature from above, providing current data on soil conditions. Sensors can be inserted into soil to continuously monitor soil moisture, pH and nutrient contents. The output is fed to integrated systems that collect the data, analyse it and support decision-making.

Shape: how to drive tech adoption for soil health

Many initiatives are tackling soil-health challenges through tech solutions that focus on areas such as soil erosion, agronomic advice and digitalization. While some of these initiatives tend to collaborate or work with the same farmer organizations, there is need for a streamlined approach that allows for greater impact. A functional ecosystem should be interoperable, contextual and collaborative:

– It must allow stakeholders to easily collect and get insights from the available data (interoperability).

– It must use technologies that consider the requirements of users in different geographies (contextual).

– It must create a trusted space to exchange ideas and work together on the emerging problems in soil health (collaboration).

These pathways would allow the scaling of relevant solutions to reach more farmers. Some initiatives under development in Africa offer examples:

– **Managing soil erosion:** It is vital to prevent erosion to preserve the integrity and fertility of agricultural lands. Techniques such as contour ploughing, terracing and conservation agriculture – including minimal tillage and cover-cropping – are instrumental in enhancing soil structure. The Coalition of Action 4 Soil Health (CA4SH) is advocating for multistakeholder actions, including investment, to scale up healthy soil practices.[42]

– **Access to agricultural knowledge and agronomic advice:** Crops require healthy soil to be productive, in addition to quality inputs and fertilizers, and different crops can be sustainably grown only on certain types of land. Vision for Adapted Crops and Soils (VACS) aims to reverse soil degradation by increasing access to knowledge and information at the farm and field levels, enabling informed decisions about what to grow, where to grow it and which soil-management practices to apply.[43] At the same time, the Global Soil Doctors Programme supports access to adequate agronomic advice by offering a farmer-to-farmer training platform and improving farmers' capability to manage soil health independently.[44] This includes tailored guidance on soil management, crop rotation and pest control.

– **Digital agriculture:** The expansion of digital agriculture from pilot projects to large-scale adoption is crucial to improving the sustainability and efficiency of farms and fertilizer usage. Priority topics include promoting digital awareness, improving access and encouraging data-driven agriculture.[45] Organizations such as FAO, CGIAR and the Africa Soil Information Service (AfSIS), along with new initiatives such as SoilHive by Varda, are working on pivotal collaborations that are providing the necessary data for informed agricultural decisions.

Scale: Effective capacity-building and investments

The variability in biophysical, socioeconomic and cultural contexts means that data ecosystems must be tailored to specific contexts before they can be scaled. Focus areas are on human and institutional capacity-building, sustainable investments and policy and regulation.

Human and institutional capacity: There is a need to develop training programmes for farmers and agricultural workers on technology use and deployment.

– Multisectoral and multigeographical collaborations and knowledge-sharing support the exchange of information and useful experiences that could work in multiple areas.

– Agricultural extension services must be scaled to offer support to farmers, creating a network of local experts for customized guidance. In many instances, AI and data tools can be an enabling mechanism to drive decision-making and advisory services.

– Community engagement is crucial in promoting collective action.

Sustainable investments: Investment is required to accelerate the diffusion of innovation.

– Public, philanthropic and private co-investment is important alongside robust credit facilities.

– Investment in infrastructure development such as irrigation systems, storage facilities and transport networks improves access to markets and may encourage farmers to invest in soil health.

– Subsidizing the cost of high-tech soil health technologies and promoting open-source and low-cost alternatives will enable scale.

Favourable policy and regulations: Implementing favourable policies and regulations that create incentives for the adoption of sustainable soil practices and encourage conservation through land use will help create an enabling environment for scaling. It is vital to develop standards for soil health practices and certification and enabling systems that allow for monitoring and evaluation of soil health innovations using data.

Way forward

Soil health, crucial for food supply and ecosystem services, faces severe challenges from degradation. Both low-tech and high-tech practices can provide solutions, alongside organizational capacity-building on specific topics such as preventing erosion, improving access to fertilizers and agronomic advice, and expanding digital agriculture. However, farmers – who provide a national service that should be paid for by all who benefit from it, directly or indirectly – are only part of the picture. By promoting collaboration and developing adequate coordinating frameworks following the source–shape–scale framework, soil health can be effectively and lastingly improved.

3.2 Protein innovation pathways

Introduction: The need for sustainable protein innovation

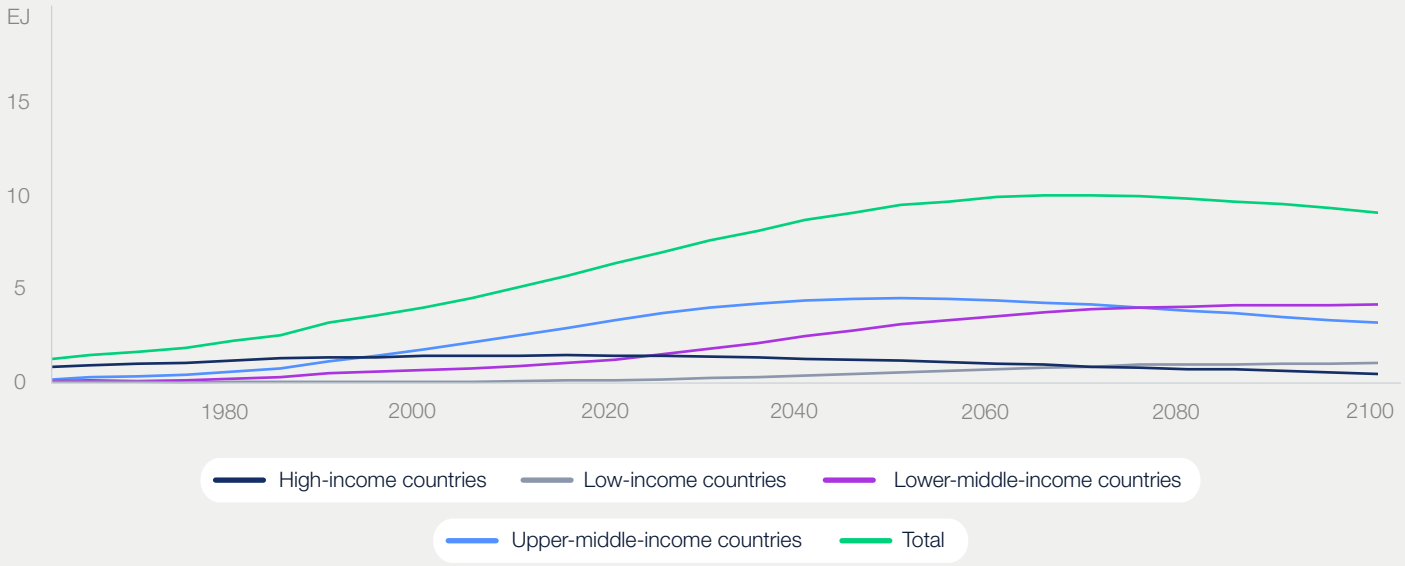
The global demand for protein – especially meat, dairy and eggs – is expected to grow significantly over the coming decades (Figure 9). Considerable environmental impact will likely result, as animal-based food production systems have the highest degree of environmental impact across a variety of metrics (Figure 9).[46] Achieving universally accessible protein will require multiple transition pathways,[47] such as:

- Accelerating protein diversification
- Advancing sustainable production systems
- Driving consumer behaviour and demand change

For the more than 800 million people that go hungry regularly, increasing the supply of safe food depends directly on new sources of production. Developing alternative protein products that are relevant and suitable in those contexts can play a key complementary role alongside traditional protein sources to alleviate malnutrition.

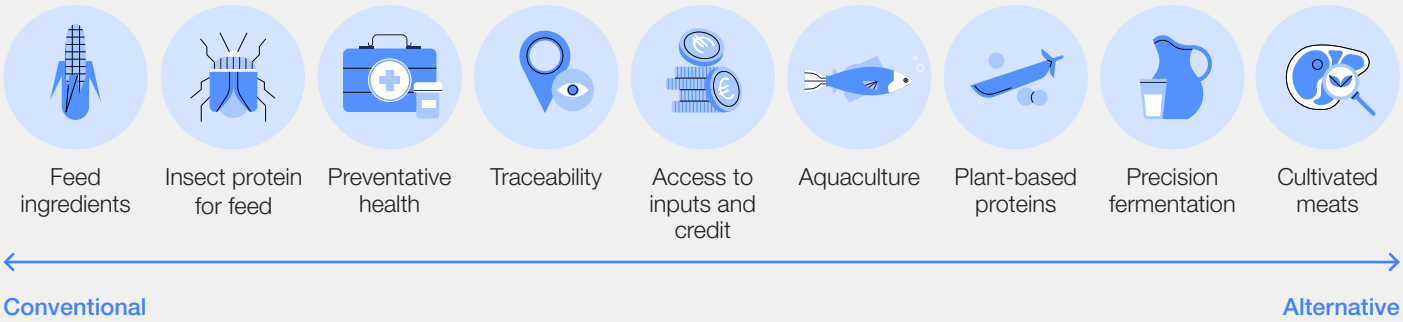
FIGURE 9 **Animal-based food consumption is expected to increase**

Total animal-based food energy demand projection per region over time (in EJ)



Source: OECD, *Agricultural Outlook 2021–2030*; Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science, 360*(6392), 987–992.

FIGURE 10 | **Landscape of protein innovation topics** (not exhaustive)



Source: BCG analysis

Conventional protein pathways

Animals are one of the fundamental sources of protein. Innovation within this conventional protein value chain is primarily focused on the farm level, with topics including animal welfare and health, and environmental sustainability. In several markets, there is a need to develop the full value chain as well as support farmers and fishers with the right access to inputs, markets and credits. Areas of innovation include the following:

- **Feed ingredients:** Innovations such as incorporating insects and mycoproteins into aquafeed can improve nutrient intake, lower footprint and improve feed conversion.[48] By making feed more sustainable, emissions can be avoided as well.
- **Preventative health:** Developing preventative health measures, such as probiotics and specialty enzymes for microbiome management aims to improve animal health overall.[49]
- **Traceability:** Using blockchain and IoT technologies in meat supply chains can ensure transparency and accountability from production to consumption.[50]
- **Access to inputs, markets and financing:** Solutions that offer access to quality feed,[51] markets and credit mechanisms allow for greater investment in sustainable practices as well as building local markets for protein.[52]

Alternative protein pathways

Alternative proteins offer options to complement conventional proteins with the goal of improving sustainability and nutrition.[53] This paper has focused on three main production platforms (Figure 11). There is significant opportunity in others such as blended proteins that need to be further examined.

FIGURE 11 **Types of alternative protein**

Source: BCG analysis

Market situation and current sector challenges

Currently, alternative proteins make up 2% of the overall protein market. To increase their adoption and allow the sector to meaningfully contribute to global food systems, it is essential to achieve competitive pricing, improve taste and texture, and maintain high nutritional value.[54]

Despite its potential, the alternative proteins sector needs to address challenges, including:

- The need for advanced technological improvements; for example, in texturizing to better replicate the sensory experience of conventional meat
- An insufficient understanding of consumer needs
- An expansion of infrastructure to support large-scale production, supportive regulatory frameworks, increased public funding and the promotion of open-source scientific research to accelerate innovation and reduce costs
- High capital expenditures and a short-term focus on venture capital investments to create financial pressures, leading to the collapse of certain start-ups in the sector

Source: R&D, technical and regulatory challenges

To provide a multiplicity of solutions through alternate proteins, the ecosystem cooperation framework of source–shape–scale demonstrates what it would take for scale and adoption.

Identification of innovative protein solutions

In this stage, innovations are nascent and require extensive R&D. Cultivated meat is an example. The focus is on establishing proof-of-concept and overcoming initial technical issues. Challenges include the following:[55]

- Developing robust and high-yield cell lines to produce cultivated meat and dairy
- Optimization of ingredients and usage of growth media to bring down costs (e.g. medium recycling)
- Lowering the energy intensity of alternative protein production systems
- Improving bioreactor design to efficiently and cost-effectively produce cultivated meat and dairy at scale (e.g. microcarriers within bioreactors), while ensuring effective delivery of nutrients (e.g. perfusion or microfluidic systems)
- Designing tissue-engineering solutions (e.g. co-culturing systems of fat and muscle cells) to replicate the texture, taste and nutritional profile of conventional meat more closely, such as scaffolds (e.g. biocompatible materials or 3D bioprinting) to create differentiation into complex tissues (e.g. steaks)
- Ensuring fit with local nutritional and taste profiles

Shape: Refining alternative proteins to meet market needs

The shape stage focuses on refining innovations to meet market needs, scale up production and gain consumer acceptance. It is crucial for ensuring that these products not only reach the market but also thrive by meeting consumer expectations in taste, texture and nutrition.

Optimizing product formulations: If companies work in isolation to solve technical bottlenecks, progress can be slow and fragmented. Therefore, collaborative R&D is essential. Through R&D, companies can enhance current technologies, focusing particularly on texture and taste.

There is evidence for investment; for instance, the alternative protein industry raised $1.6 billion in investments in 2023 and an additional $299 million in the first quarter of 2024 (Figure 12), demonstrating substantial financial support for ongoing innovation.

The refinement process is heavily influenced by consumer feedback. This iterative process ensures that product refinements align with market demands. In addition, these products should factor in the nutritional and health requirements during the refinement.

FIGURE 12 **All-time investment in alternative proteins has reached $16 billion**

Category	Invested capital Q2 2024	Invested capital 2023	Total invested capital 2015–Q2 2024
Total alternative protein	$367 M	$1.6 B	$16.1 B
Plant-based	$80 M	$908 M	$8.5 B
Fermentation	$170 M	$443 M	$4.4 B
Cultivated	$118 M	$226 M	$3.2 B

Source: Good Food Institute. (2024). *Investing in Alternative Protein*

Scale: Strategies to increase market share

The scale stage is characterized by widespread adoption and commercialization of innovations. Plant-based milk exemplifies this stage, having achieved significant market penetration and consumer acceptance. Scaling involves achieving economies of scale, enhancing distribution networks and increasing market share. In this stage, companies need to overcome challenges related to production costs, supply-chain logistics and competitive pricing.

Key lessons learned and pathways to adoption

The future offers significant innovation potential in alternative and complementary production systems. The source–shape–scale approach provides a comprehensive framework to understand the progression of the alternative protein market. In the short to medium term, the following strategies are recommended to accelerate progress.

Importance of policy support: Comparable to the growth of the electric vehicle (EV) industry, policy instruments that support new technologies and derisk adoption are essential, especially to define health, nutrition and livelihood trade-offs.[56] The cultivated meat sector, still in its infancy, is experiencing an evolving regulatory landscape. Singapore, the United States, Israel and the United Kingdom (pet food only) have approved cultivated meat sales, while the EU and Japan are developing frameworks; that most countries do not have such policies shows the widely different maturities in adopting these innovations. Ensuring safety, transparency, health, nutrition and consumer information is critical for market entry, as is investment in skills and knowledge development, especially for the more technology-enabled alternative proteins. High-capex sectors require patient capital, government funding, robust R&D and supportive regulations. Many countries are now recognizing the need for long-term investments in low and deep tech for food.[57] Pricing is a key aspect, and progress towards competitive pricing can be made through policy levers, not just by scaling. For example, many plant-based foods are charged much higher VAT than their conventional counterparts and receive lower subsidies.[58]

Role of farmers: The economic impact on farmers in the transition to sustainable protein sources must be taken into account. By integrating farmers into new production systems, a diversified source of income and new markets could be unlocked. Support mechanisms, such as training programmes, subsidies and investments in infrastructure, can facilitate this transition and help farmers become key players in the transition.

Scaling up processes through multistakeholder collaborations: Multistakeholder collaborations are essential to address the high capital expenditure (capex) and long return on investment (ROI) timelines of deep-tech industries such as alternative proteins. Governments can provide support through loan guarantees, tax incentives and grants for research and infrastructure. For instance, the EU considers alternative proteins integral to its Farm to Fork strategy. In 2022, alternative protein companies in Europe raised €579 million, a 24% increase from 2021, indicating a growing investment interest.[59]

The private sector is crucial for transforming R&D innovations into market-ready products. Corporations can enter into offtake agreements for future delivery of new ingredients or products, adapting their supply chains to integrate these new components. Such agreements signal growing market demand, encouraging suppliers to scale up production. These collaborations can also support the following:

Achieving economies of scale: This involves optimizing manufacturing processes (e.g. increased automatization and effective resource allocation and supply-chain management), investing in advanced technologies (e.g. food processing and biotechnology) and improving operational efficiencies (e.g. eliminating waste and enhancing productivity). Project investors play a vital role in unlocking economies of scale by providing the necessary financial backing.

Enhancing distribution networks: To enhance distribution networks, strategic joint ventures and partnerships must be formed with established food companies, such as consumer packaged goods companies, civil society and local players, to make the most of market presence and fit. Additionally, participating in market access programmes can provide funding and support for commercialization efforts. Finally, establishing robust sales channels, both offline and online, is essential to cater for diverse consumer preferences.

Increasing market share: To capture a larger market share, it is crucial to focus on comprehensive commercialization strategies, including through public procurement. Strategic partnerships and acquisition of new technologies alongside effective marketing and branding campaigns are needed for consumer retention. For example, Oatly, a Swedish oat milk company, optimized its production, used effective marketing and partnered with companies such as Starbucks and Reitan to leverage its extensive distribution networks and get its products into supermarkets and cafés globally.[60]

Way forward

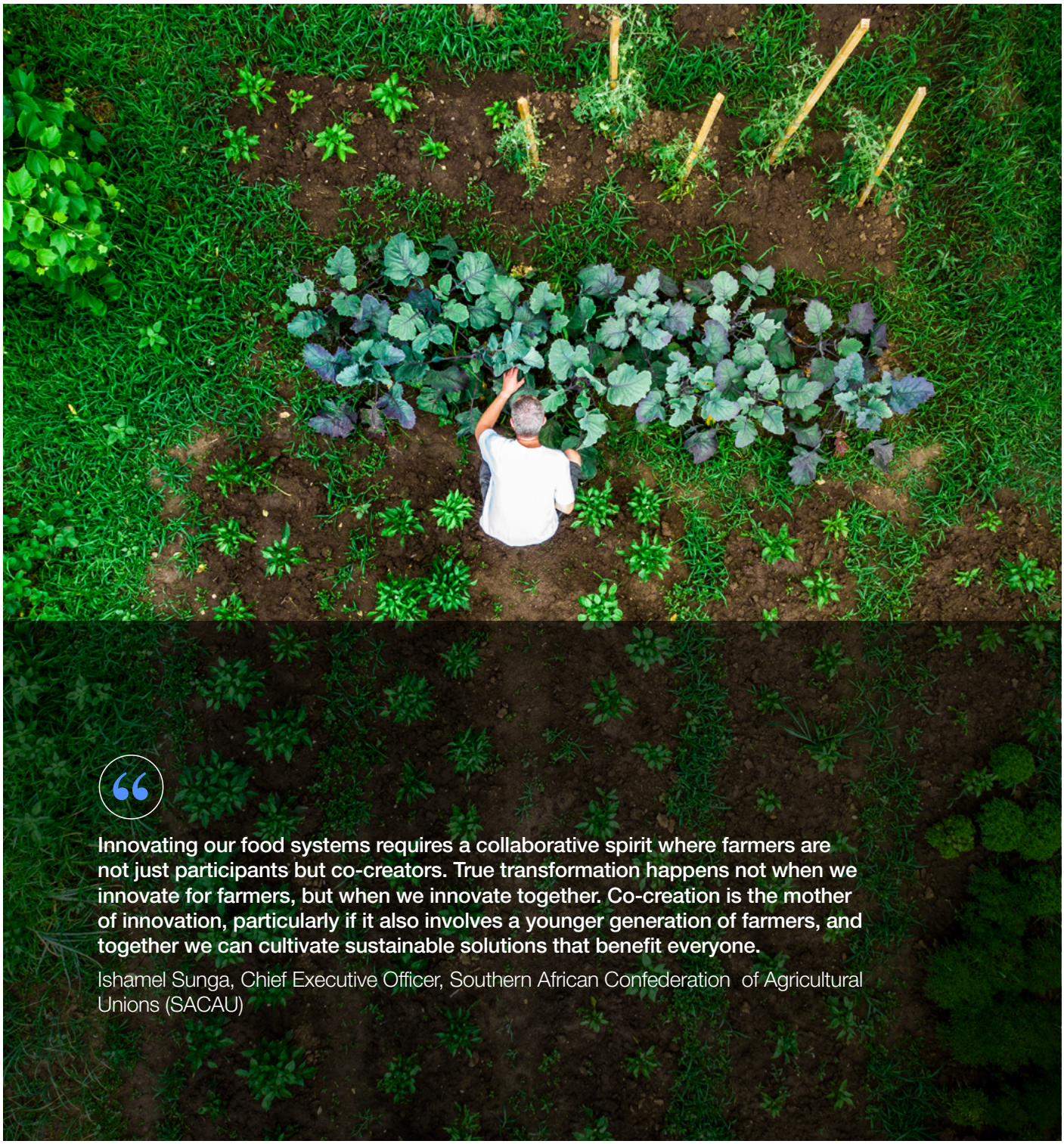
By promoting collaboration among stakeholders, bringing farmers and consumers into the co-design process and develop new market opportunities, the alternative protein industry can offer effective solutions for a sustainable and inclusive food future – as well as improving the conventional protein value chain.

While investing in innovation in traditional agriculture is necessary, countries need a diversified portfolio of solutions to reduce the risks and create protein production processes that are resilient to climate change. Moreover, mainstreaming alternative proteins is one of the many solutions alongside building inclusive and sustainable conventional production pathways. The transition is likely to occur in a phased approach, whereby alternative proteins may at first provide complementary options before partially substituting some areas of animal-based proteins over time. A successful system will have to navigate the trade-offs particular solutions will bring. Significant research, collaboration and alignment is required to understand the economic cost and trade-offs vis-à-vis farmer livelihoods, environments and diets.

4

Call to action: Mainstreaming food innovation

Decisive and coordinated action is needed to mainstream food innovation.

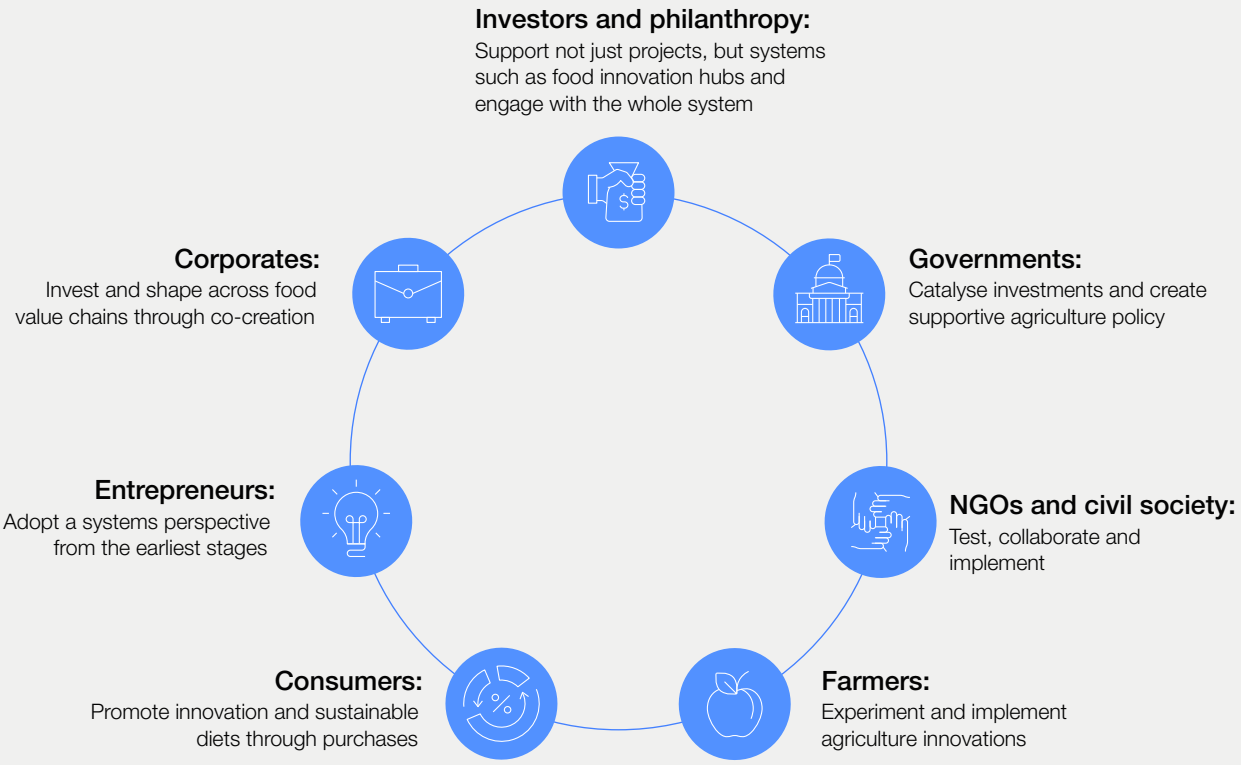


Innovating our food systems requires a collaborative spirit where farmers are not just participants but co-creators. True transformation happens not when we innovate for farmers, but when we innovate together. Co-creation is the mother of innovation, particularly if it also involves a younger generation of farmers, and together we can cultivate sustainable solutions that benefit everyone.

Ishamel Sunga, Chief Executive Officer, Southern African Confederation of Agricultural Unions (SACAU)

From farmers to consumers, every stakeholder has a part to play in mainstreaming food innovation (Figure 13).

FIGURE 13 **Stakeholder roles in the innovation ecosystem**



Source: BCG analysis

BOX 3 | **Role of stakeholders in the food innovation ecosystem**

Private sector

- Invest in food systems innovation, for both financial and impact opportunities, through both R&D and direct investments.
- Use expertise in specific market areas to shape innovations by co-creating and providing access to innovations.
- Engage with the system as a whole, investing in partnerships and hubs.
- Champion sustainable and innovative business models and intrapreneurship.

Farmers

- Co-design, experiment with and implement innovations wherever possible, sharing knowledge of and insights into needs and environments.
- Adopt best practices in terms of sustainability and technology as applicable.
- Grow the crops necessary to fuel the various transitions, including alternative proteins.
- Invest in the technologies and innovations to build a more sustainable food production system.

Governments

- Generate longer-term collaboration among farmers, academia and industry by using governments' access to scale.
- Create micro-environments to develop innovations and ensure they become fit for purpose (e.g. through model farms, laboratories and sandboxes).[61]
- Provide regulatory and financial incentives, as well as foundational infrastructure, to enable innovation to thrive.
- Provide catalytic funding for innovators, where possible, and support for public research and academia on food innovation.

NGOs and civil society

- Hold dialogues with local communities to understand their needs and help shape innovations.
- Act as intermediaries and neutral project managers on platforms and hubs, connecting innovators with funding opportunities and other necessary resources.
- Help roll out innovations on the ground and support local tailoring of projects and help broker fair value-chain exchanges for their respective communities.

Innovators

- Develop innovative solutions to make food systems more efficient, productive, resilient and sustainable in response to the identified needs of the system.
- Proactively engage with intended end users, such as farmers, to fully understand any uptake issues with their solutions.
- Seek out high-potential funding and partnership opportunities to enable their technologies to scale.

Financial institutions

- Invest in systems, not just individual projects; for example, by supporting hubs, research and communities.
- Invest in food innovation with a long-term perspective to help overcome the short-term ROI challenges observed.
- Source innovations with high scalability and sustainability potential and thereby ensure that investments not only grow but also help tackle the problems they are designed to solve.

Consumers

- Promote innovation through purchases and send a signal to systems to engage in innovation.
- Demand transparency throughout the value chain of food innovation to motivate companies to improve their practices.
- Adopt more sustainable diets to improve the sustainability of the entire food value chain and demand access to sustainable, healthy diets.
- Advocate for change at local, national and global levels, pushing for regulations and incentives that create environments in which food innovations can flourish.

By unifying efforts, coalitions of aligned partners can ensure that food innovations can deliver on their promise to create a food system transformation that is not only environmentally resilient but also contributes to the transformation of the lives of all stakeholders involved, especially primary producers and consumers.

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Grow Asia

ID Capital

Majid Al Futtaim

Mastercard

Mercy Corps – Agrifin

Microsoft

PepsiCo

Solvable Syndicate

Soma Mater

Syngenta Foundation

Tastewise

The Good Food Institute

United Nations World Food Programme

Upfield

UPL

World Farmers' Organisation

Production

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Endnotes

1. Detailed sources are provided in the main chapters.
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