Article 5

Novel Agrifood Technologies &
Sustainable Development Article Series

UNDP

ALTERNATIVE PROTEINS IN THE DEVELOPMENT CONTEXT: A GROUNDED PERSPECTIVE ON EMERGING OPPORTUNITIES AND CHALLENGES

INTRODUCTION

Within the wider landscape of agrifood innovation, alternative proteins have emerged as an area with significant attention from both start-ups and multinationals over the past decade. While global investment peaked in the early days and has since slowed amid shifting market conditions, alternative proteins continue to hold a promise of reshaping how we produce protein.

One of the most compelling reasons in support of alternative proteins is that it is increasingly seen as a key lever for reimagining the future of food – one that could decouple protein production from the environmental costs of conventional animal agriculture.

While much of the conversation around alternative proteins has been driven by high-income markets, there is growing interest in what these innovations could mean for low- and middle-income countries (LMICs). **Can alternative proteins contribute sustainably and meaningfully in the development context, particularly in the LMICs' food systems?**

In light of this, this article looks beyond the hype to take a more grounded look at alternative proteins through the lens of three interconnected priorities for LMICs: climate resilience, nutrition security, and inclusive livelihoods. These are the areas where alternative proteins could potentially make the greatest difference, if innovation is thoughtfully adapted to the context, while making considerations regarding the challenges and trade-offs associated with its adoption surrounding affordability, inclusion, and socioeconomic complexity, amongst others.


Photo: Canva

UNDERSTANDING ALTERNATIVE PROTEINS

In this article, alternative proteins refer specifically to technologically advanced protein products designed to replicate the taste, texture, and nutrition of conventional animal proteins, but produced without animals.[1] Notably, this definition excludes long-standing plant-based staples like tofu or tempeh. The focus of the article is on novel technologies unlocking new markets, products, and pathways.

Novel technologically-advanced alternative proteins broadly fall into three categories:

Plant-based protein

They represent the most established and recognizable category of alternative proteins currently. They are produced by isolating proteins from plant sources, predominantly legumes such as soybeans, field peas, and chickpeas, and subjecting them to industrial processes such as extrusion to achieve textures, tastes, and cooking properties reminiscent of animal proteins.[2] Products like plant-based burger patties, nuggets, and dairy-free milk fall into this category. They already represent a significant and growing share of the alternative protein market globally.

Cultivated meat

Still in its infancy and also known as cultured meat, innovators in this field are pioneering a distinct approach: producing meat and seafood directly from animal cells without the need for the entire animal. This process entails isolating animal cells and cultivating them in a bioreactor or similarly safe and controlled environment until they form tissues suitable for consumption. As of June 2025, cultivated meat is primarily sold in Singapore, the United States, and Australia.[3] While the technology holds immense potential, it faces challenges in cost, scalability, and consumer acceptance.

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[1] Jafarzadeh, Shima, Zeinab Qazanfarzadeh, Mahsa Majzoobi, Samira Sheiband, Nazila Oladzadabbasabad, Yasaman Esmaeili, Colin J Barrow, and Wendy Timms. 2024. "Alternative Proteins; a Path to Sustainable Diets and Environment." *Current Research in Food Science* 9 (100882): 100882–82.
[2] Ibid
[3] Swartz, Elliot. 2022. "The Science of Cultivated Meat." The Good Food Institute. 2022.

Fermentation-derived products

Fermentation has long been part of food production, such as yogurt, cheese, or soy sauce. However, its role in the future of protein is rapidly expanding through new applications in food science. Fermentation-derived proteins rely on microbial processes to convert feedstocks into high-value ingredients or whole proteins.[4] There are two important sub-categories here:

- **Precision fermentation:** This approach uses select microorganisms (such as yeast or fungi) to produce specific functional ingredients from proteins and enzymes to fats, flavorings, and vitamins. Precision fermentation has already revolutionized sectors like pharmaceuticals (e.g., insulin production for diabetic patients) and is now enabling the production of animal-free dairy proteins (such as casein and whey) and egg proteins.[5] A familiar example is rennet, traditionally sourced from calf stomachs for cheese-making, but now commonly produced via engineered yeast.[6]

- **Biomass fermentation:** This method cultivates entire microorganisms, typically fungi or algae, for their naturally high protein content and fast growth rates.[7] The resulting biomass can be used directly in food products as a rich source of protein, fiber, and other nutrients. Mycoprotein, used in products like Quorn, is a well-known example.[8]

Why this Distinction Matters for LMICs?

Understanding these categories matters because their relevance differs across contexts. Plant-based proteins can leverage existing agricultural systems and are likely the most immediately scalable for LMICs. Biomass fermentation offers mid-to-long-term promise for localized, circular protein production. Cultivated meat, while groundbreaking, remains a longer-term prospect for most LMIC markets due to infrastructure and cost barriers.

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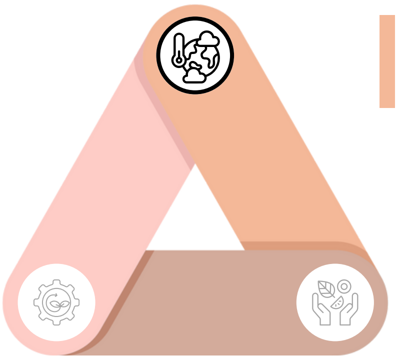
[4] The Good Food Institute. "Fermentation for Alternative Proteins." Accessed July 22, 2025.
[5] The Good Food Institute. 2023. "2023 State of the Industry Report - Fermentation: Meat, Seafood, Eggs, and Dairy."
[6] Pozas, Natalia Suescun, and Caroline Bushnell. 2020. "Fermentation: The next Frontier of Alternative Proteins." World Economic Forum. November 19, 2020.
[7] The Good Food Institute. "Fermentation for Alternative Proteins." Accessed July 22, 2025.
[8] The Good Food Institute. 2023. "2023 State of the Industry Report - Fermentation: Meat, Seafood, Eggs, and Dairy."

ALTERNATIVE PROTEINS THROUGH THE LENS OF THREE INTERCONNECTED PRIORITIES FOR LMICS



1. Alternative Proteins and Climate Resilience

From a climate lens, these novel proteins have gained traction not only for their mitigation potential, but also for the prospective role they play in enhancing food system and climate resilience, especially in LMICs that face these vulnerabilities acutely.

In regions already grappling with the impacts of climate change, such as Sub-Saharan Africa, South Asia and parts of Latin America[9], livestock systems are increasingly under strain from drought, pasture degradation, and disease spread, among others. In addition, the environmental footprint of livestock is significantly high at 14.5% global greenhouse gas (GHG) emissions.[10] In these contexts, shifting some protein production toward lower-emission alternatives could reduce environmental pressures while providing a degree of supply diversification.

Yet, climate resilience is not just about reducing emissions. It is also about ensuring that food systems can adapt to and recover from shocks. Alternative proteins may offer several resilience-enhancing features, such as:

- **Decentralized production models**, particularly in biomass fermentation and plant-based protein processing, could allow LMICs to develop regional supply chains less dependent on global feed markets or temperature-sensitive livestock systems.
- In 2020, 37.5% of global cereals were used for animal feed.[11] **Reduced reliance**

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[9] IPCC. 2019. "Chapter 5 - Special Report on Climate Change and Land." Special Report on Climate Change and Land. 2019.
[10] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. "Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities." Food and Agriculture Organization of the United Nations (FAO), Rome.
[11] Our World In Data, 'Share of cereals allocated to animal feed, 2021,' accessed July 8, 2024.

on feed grains could help buffer food systems from global price volatility and land-use constraints, both of which are exacerbated by climate stressors.

- **Diversification in food systems**, featuring alternative protein-based diets, produced in low-GHG emission systems can present opportunities for adaptation and mitigation, while also co-benefiting human health.[12] This is because the supply-side action of alternative protein-based diet production is combined with demand-side interventions such as modification of food choices and reduction of food loss and waste, leading to such alternative proteins being a key strategy.[13]

In this light, alternative proteins may represent a potential complement to existing climate resilience strategies, helping to diversity yet provide reliable sources of high-quality nutrition, and reduce the vulnerability of the agricultural supply chains.

However, the case for alternative proteins must be considered with important caveats.

First, many LMICs rely heavily on mixed farming systems where livestock contribute not only food but also livelihoods, draft power, manure, and cultural value.[14] Therefore, a complete and drastic transition away from livestock would not only be economically disruptive, but could undermine other dimensions of rural resilience if not carefully managed.

Second, technologies such as cultivated meat or precision fermentation remain capital-intensive and energy-dependent, raising questions about their scalability in low-resource settings. For example, cultivated meat production currently requires high-purity bioreactor environments and growth media, often derived from fossil fuel-based inputs – an issue still under research for more sustainable alternatives.[15]

Third, resilience also hinges on social acceptance and dietary patterns. In many LMICs, plant-based staples, derived from crops like cereals or starches, already serve as primary protein sources.[16] Thus, alternative proteins should not be viewed as replacements, but as complementary options that can enhance diversity and buffer vulnerabilities in certain contexts.

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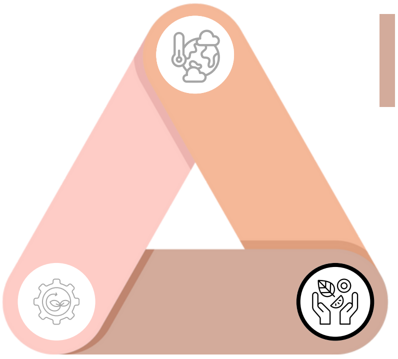
[12] IPCC. 2019. "Summary for Policymakers — Special Report on Climate Change and Land." Special Report on Climate Change and Land. 2019.
[13] IPCC. 2019. "Chapter 5 - Special Report on Climate Change and Land." Special Report on Climate Change and Land. 2019.
[14] Herrero, M., Henderson, B., Havlík, P. et al. 2016. "Greenhouse gas mitigation potentials in the livestock sector." *Nature Climate Change* 6, 452–461.
[15] Humbird D. 2021. "Scale-up economics for cultured meat." *Biotechnol Bioeng*. 2021 Aug;118(8):3239-3250.
[16] Vissamsetti N, Simon-Collins M, Lin S, et al. 2023. "Local Sources of Protein in Low- and Middle-Income Countries: How to Improve the Protein Quality?" *Current Developments in Nutrition*, Dec 21;8(Suppl 1).



2. Alternative Protein and Nutritional Security

Malnutrition remains one of the most pressing global health challenges, with protein deficiency continuing to affect millions, particularly in LMICs. The challenge is multifaceted. It is not only about total food availability, but about access to affordable, high-quality proteins that are both digestible and culturally acceptable.

Nearly half of child deaths (under 5 years of age) globally are attributed to undernutrition.[17] In LMICs, particularly in Sub-Saharan Africa and South Asia, stunting and wasting are persistent due to insufficient intake of essential nutrients, including high-quality proteins.[18] Approximately one billion people worldwide lack access to adequate protein[19], often consuming diets heavily reliant on staple grains that are insufficient in essential amino acids.

This deficiency is compounded by two key factors:

- **Limited availability of protein:** Many LMIC populations typically base their diets mainly on staples such as cereals and starches, accounting for 49% of the diet.[20] However, these staple crops may not contain all necessary nutrients as they often lack one or more essential amino acids. Since traditional legumes offer partial solutions and require dietary pairing, which may not be feasible in contexts of low-income and food insecurity, there is an increasing risk of protein inadequacy, potentially leading to what is known as "protein gap".[21]
- **Elevated nutritional needs in high burden contexts:** Poor sanitation, high disease burdens, and limited healthcare access increase nutrient losses and elevate dietary requirements. This means even the same quantity of protein may be insufficient in contexts of chronic illness or environmental stress, such as exposure to diarrheal disease or parasitic infections.[22]

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[17] WHO. 2021. Malnutrition Fact Sheet.
[18] Rose Paro F, Davour R, Acosta D et al. 2025. "Improving Nutrition Security in Low- and Middle-Income Countries and the Role of Animal-Source Foods." *Annual Review of Animal Biosciences* Vol. 13:371-388.
[19] FAO, IFAD, UNICEF, WFP and WHO. 2019. "The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns." Rome, FAO.
[20] Vissamsetti N, Simon-Collins M, Lin S, et al. 2023. "Local Sources of Protein in Low- and Middle-Income Countries: How to Improve the Protein Quality?" Current Developments in Nutrition, Dec 21;8(Suppl 1).
[21] Ibid
[22] FAO. 2025. "Environmental Stressors and Protein Utilization." Accessed July 23, 2025.

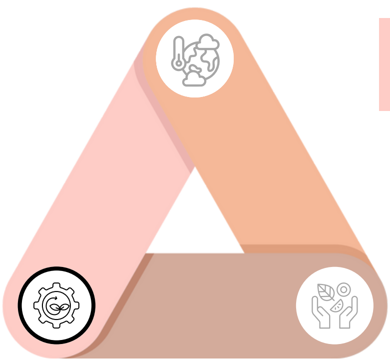
In this context, alternative protein technologies could offer targeted innovations to supplement and strengthen diets, though not as standalone solutions. Their value lies in complementing existing food sources by offering new, potentially affordable, and scalable protein options. Some examples of how alternative proteins are offering targeted solutions for nutrition security are presented below:

- In December 2020, the **UNDP Accelerator Lab India** organized the *Innovate4SDG* competition to promote pioneering innovations in food systems aligned with Sustainable Development Goals (SDGs). As part of the initiative, a team from the Indian Institute of Technology (IIT) Delhi's Centre of Rural Development & Technology developed a novel plant-based egg alternative that closely replicates the protein content, taste, texture, and appearance of conventional chicken eggs.[23] Their solution was awarded as the winner in the competition for introducing a new sustainable dietary option that also addresses affordability and accessibility challenges in India's nutritional landscape. Such innovations support the potential of alternative protein technologies to ensure nutritional security in a sustainable manner, while benefitting livelihoods.
- **Nigeria's VeggieVictory**[24] stands as the country's first plant-based startup making alternative proteins culturally relevant and accessible in Africa. It is innovating with plant-based protein products like VChunks, which is a dehydrated meat alternative specifically designed for local cuisine preferences. In addition to product innovation, VChunks is set to appeal to traditional tastes, which indicates that the company is engaging in awareness-raising efforts to build consumer understanding and acceptance of plant-based proteins in local diets. This is an important step given the cultural embeddedness of meat in many cuisines. It has been garnering investments from around the world with a vision to contribute to environmental sustainability, social fairness, and animal cruelty-free.[25]
- **Essential Impact**[26] is developing low-cost fermentation technologies to produce protein-rich biomass, particularly in East Africa, with the mission to tackle malnutrition and transform food systems. These innovations aim to integrate alternative proteins into affordable, nutritious products for local markets.

By contrast to these limitations, a model example is of Singapore, which has taken a science-based, proactive approach. In 2019, the Singapore Food Agency (SFA) introduced

[23] UNDP, "Innovating food systems to provide nutritional security to the nation while saving the planet," May 12, 2023.
[24] "Our Story: VeggieVictory," accessed July 22, 2025
[25] Ho, Sally. 2021. "VeggieVictory: Global Investors Back Nigeria's First Plant-Based Food Tech in Pre-Seed Round." Green Queen. February 12, 2021.
[26] "Who We Are: Essential," accessed July 22, 2025.

the novel food regulatory framework that requires companies to undergo a pre-market safety assessment for foods without a history of consumption, such as cultivated meat and fermentation-driven proteins.[27] This includes evaluating risks related to toxicity, allergenicity, production methods, and dietary exposure, along with documentation of manufacturing controls. This framework laid the foundation for Singapore's 2020 approval of cultivated chicken – making it the first country in the world to authorize the commercial sale of cultivated meat following rigorous evaluation.[28] The Codex Alimentarius Commission is also currently considering the development of guidelines on the safety of cell-based foods, which can help regulators including those in LMICs navigate the food safety challenges of regulating these new foods.[29] Such examples illustrate how enabling regulation can accelerate innovation while safeguarding public health.



3. Alternative Proteins and Inclusive Livelihoods

Smallholder farmers, who manage around 84% of the world's farms but often operate on less than two hectares of land[30], are vital actors in LMIC food systems. Specifically in Sub-Saharan Africa and Asia, an estimated 80% of the farmland is managed by smallholders (working on up to 10 hectares).[31] They contribute significantly to local food security, biodiversity, rural economies,

As alternative protein markets begin to evolve beyond high-income contexts, a key question arises: *what role, if any, might smallholder farmers play in this transition in order to achieve inclusivity and ensure these crucial actors are not left behind?*

Several potential pathways exist, though each comes with preconditions and trade-offs.

- **Supplying raw ingredients for plant-based proteins:** Some smallholders already cultivate protein-rich crops such as soybeans, peas, chickpeas, lentils, and amaranth - many of these serve as key inputs for plant-based protein production. With targeted investment and improved market linkages, there may

[30] Sarah K. Lowder, Marco V. Sánchez, Raffaele Bertini. 2021. "Which farms feed the world and has farmland become more concentrated?" *World Development*, Volume 142, 105455, ISSN 0305-750X.
[31] FAO. 2012. "Sustainability Pathways: Smallholders and Family Farmers (Factsheet)."

be opportunities to strengthen value chains that source these crops for local or regional processing. However, the profitability of such integration depends on secure offtake agreements, access to quality seeds, and support for post-harvest handling and aggregation.

- **Providing feedstocks for fermentation-based systems:** Biomass and precision fermentation technologies require various carbon-rich feedstocks, such as sugarcane juice, sorghum, cassava starch, or agricultural residues. Where fermentation infrastructure is being piloted, smallholders could serve as decentralized suppliers of these inputs. This may be particularly relevant in circular economy models that valorize agricultural waste or co-products. Yet, this potential is contingent on the development of local bioprocessing hubs, the cost-efficiency of feedstock logistics, and equitable benefit-sharing mechanisms. Without these, smallholders may face extraction rather than inclusion.
- **Enabling diversification and risk management:** Alternative protein value chains could offer smallholders new income sources that help spread climate and market risks. For example, intercropping high-protein legumes alongside staple crops can enhance soil fertility, increase dietary diversity, and open niche market opportunities. Such diversification, however, requires extension services, local demand signals, and storage solutions in LMICs.

On a cautionary side, proprietary technologies, capital intensity, and urban-centric business models may inadvertently entrench existing inequalities and vulnerabilities in the agrifood system when adopting alternative protein as a growing market unless deliberate inclusion strategies are embedded early on. Therefore, smallholder farmers can be integrated as potential contributors and key actors of the broader ecosystem of protein innovation.


Photo: UNDP Paraguay

CONCLUSION: NAVIGATING CHALLENGES, AND PATHWAYS FORWARD FOR ALTERNATIVE PROTEINS IN LMICS


Photo: UNDP Kyrgyz Republic

As this article has explored, alternative proteins may offer pathways for climate resilience, improving nutrition, diversifying livelihoods in LMIC food systems, amongst others. However, their potential lies not just in the technologies themselves, and instead in how they are adapted, governed, and integrated into local development priorities.

Rather than embracing or rejecting alternative proteins outright, LMICs, in their development context, may find value in sequencing the adoption of alternative proteins in the short-, mid-, and long-term. Piloting near-term solutions using existing infrastructure by considering the trade-offs earlier mentioned can be beneficial. Over time, investing in more complex systems, strategically experimenting with models that fit local contexts, building inclusive regulatory systems, and investing in innovation that is both locally led and globally informed is also key.

Having said that, there is a risk that LMICs could become sites of extraction, supplying raw ingredients or feedstocks for alternative protein production elsewhere, without capturing value or building local capabilities. This pattern, familiar from other sectors, can deepen dependency rather than promote self-reliance. Government arrangements that prioritize local processing, fair trade standards, and reinvestment in regional innovation capacity is instrumental.

By advancing these nuanced, context-specific approaches, alternative proteins have the potential to serve as a critical tool for climate resilience, improving food security, and livelihoods in LMICs.

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