Charting India's Protein Transition

Building resilient food systems for a secure future

September 2026

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Message from the Federation of Indian Chambers of Commerce and Industry

Ms. Jyoti Vij
Director General,
FICCI

India stands at an important juncture in shaping the future of its food and protein systems. As population, incomes, and dietary preferences evolve, the demand for nutritious, affordable and accessible sources of protein is expected to grow. Against this backdrop, this report "Charting India's Protein Transition" offers a timely perspective on how India can respond to this changing landscape while advancing food security, resilience, and sustainability.

India's protein transition will be distinct, reflecting the diversity of its food systems and consumption patterns. Pulses, cereals, dairy, eggs, fish, meat, and emerging alternative proteins each contribute differently to nutrition, livelihoods and the use of natural resources. This diversity presents an opportunity to pursue multiple pathways rather than a single approach, while recognising the varying implications of each for the environment, economy, and society.

The transition will require greater efficiency, resource optimisation, innovation, and diversification across the protein value chain. At the same time, considerations relating to climate change, water and feed availability, food safety, livelihoods, and economic resilience will need to be addressed in a balanced manner. Ensuring that farmers, industry, and other stakeholders are able to participate meaningfully in this evolving ecosystem will be equally important.

The objective shall be to ensure that rising protein demand is met through systems that are efficient, resilient, and sustainable. India can build on its strengths in traditional protein sources, scientific and technological capabilities, manufacturing capacity, and evolving policy frameworks to support this transformation and develop future-ready food systems.

I am confident that this report will contribute to the national dialogue on India's protein future and provide valuable perspectives for informed discussion, collaboration, and future action.

I congratulate all the contributors to this important study and look forward to its findings contributing to the continued development of India's food and protein systems.

Message from the Confederation of Indian Food Trade and Industry

Mr Tarun Arora
President,
CIFTI-FICCI

India's food system is undergoing a significant transformation, driven by changing consumer preferences, evolving dietary patterns, technological advances, climate-related challenges, and the need to ensure food and nutrition security for a growing population. In this context, ensuring access to adequate, affordable, and nutritious sources of protein is emerging as an important national priority.

This report, "Charting India's Protein Transition", presents an important perspective on the evolving protein landscape in India and the choices that will shape the country's food system in the decades ahead. As highlighted in the analysis, per-capita protein consumption is projected to increase substantially, making the manner in which this demand is met an important consideration for nutrition, food security, industry, and sustainability.

The findings point towards the importance of combining improvements in production efficiency with greater protein diversification. The report's modelling indicates that such an integrated approach can materially reduce emissions compared with a business-as-usual pathway. At the same time, resource efficiency, food safety, traceability, public health, animal welfare, and the resilience of supply chains will need to remain integral to the transition.

The report is therefore an important contribution to the ongoing national dialogue on India's protein future. It can help stakeholders better understand the interconnections between protein security, nutrition, sustainability, resilience, and economic opportunity, and encourage evidence-based approaches to policy and business decisions.

A successful protein transition must, however, be inclusive, science-based, and consumer-centric. Environmental sustainability and emissions reduction are important considerations, but they need to be pursued alongside affordability, nutritional adequacy, food safety, consumer preferences, and the livelihoods of farmers and other stakeholders across the value chain.

The report provides a useful basis for continued engagement among industry, policymakers, researchers, and other stakeholders. At CIFTI, we look forward to contributing to discussions that support improved nutrition, innovation, competitiveness, and a resilient and sustainable food industry.

Once again, I congratulate the authors and all stakeholders associated with this important research and wish the report success in contributing to the ongoing national discourse on India's protein future.

Foreword

India's growing population, rising incomes and changing dietary preferences are expected to significantly increase the demand for protein. Meeting this demand while strengthening nutrition security, safeguarding livelihoods and managing pressure on climate and natural resources will be important to India's journey towards Viksit Bharat 2047.

Industry has a vital role in this transition. Businesses can contribute through resource-efficient production, resilient supply chains, responsible sourcing and greater investment in traditional and emerging protein solutions. These actions are both a sustainability responsibility and a strategic opportunity for long-term competitiveness.

Charting India's Protein Transition presents possible pathways for meeting India's future protein needs. It highlights the value of combining improvements across dairy, poultry and seafood systems with a stronger role for pulses, other traditional plant proteins and emerging alternatives.

We hope this report encourages businesses, financial institutions and policymakers to work together towards a protein-secure, resilient and sustainable future for India.

– Rituj Sahu, Director, Protein Transition/ Sustainable Food Systems (India), ARE

– Kate Blaszak, Director, Protein Transition/ Sustainable Food Systems, ARE

Executive Summary

India's protein system is entering a decisive decade. Average annual per capita protein consumption is projected to rise from 9.5kg in 2025 to 30kg by 2070 — a level that would exceed current Planetary Health Diet reference levels, even as large sections of the country face protein insecurity. This surge is being driven by population growth, rising incomes, urbanisation, public nutrition programmes, and shifting dietary preferences.

The country's sheer scale means even modest increases in per-capita consumption translate to significant absolute demand growth.

At the same time, improving protein access and security remains central to India's development agenda. Cereal-heavy diets, persistent malnutrition, and limited access to diverse and protein-rich food remain significant issues, particularly for lower-income households. The challenge is to meet future demand in a resilient and efficient way without deepening climate, nature, water, public health, livelihood, and other social risks.

Given the pace of change in India's food system, the original 2023 modelling done by ARE has been refreshed to reflect updated datasets, deeper India-specific analysis, and wider consultation with external thematic and food systems experts. The report assesses four potential pathways for India's protein system through 2070:

- **a business-as-usual (BAU) pathway;**
- **a production mitigation pathway** based on ambitious supply-side interventions;
- **a demand diversification pathway** that substitutes a growing share of conventional animal protein demand with emerging protein alternatives, while traditional plant proteins continue along their baseline growth trajectory;
- **an integrated transition pathway** that builds sequentially on the production mitigation and demand diversification pathways by adding stronger traditional plant-protein consumption and healthier long-term demand boundaries.

“Under a business-as-usual pathway, India’s protein-related emissions are projected to reach 1.92 Gt CO^2e a year by 2070, more than seven times the estimated climate-safe threshold…”

Drawing on parameters from the Science Based Targets Initiative’s (SBTi) *Food, Land and Agriculture Guidance (2022)*, the analysis explores how different pathways affect emissions, resilience and protein security. What we find is that India’s protein transition will look very different from many Western markets, which have saturated supply via industrial animal production and need to urgently diversify to reduce reliance on resource-hungry and climate-damaging systems.

India’s protein demand is expected to retain its traditional anchors in dairy and pulses, accompanied by significant growth in eggs, poultry, and seafood. Red meat remains a relatively small part of the story. So, unlike many Western countries, India does not face a singular livestock transition but rather multiple simultaneous transitions across fragmented, smallholder-led dairy systems, commercially concentrated poultry, heterogeneous seafood systems, traditional plant proteins, and emerging alternative proteins.

The scenarios laid out in this report should be read as modelling pathways, not forecasts. They rely on ambitious assumptions about long-term mitigation potential, technology deployment, production efficiency, demand diversification, and climate-safe emissions thresholds adapted to the Indian context. The analysis is primarily based on domestic consumption-driven production and does not fully account for export-oriented production, particularly in seafood.

Under a BAU pathway, India’s protein-related emissions are projected to reach 1.92 gigatonnes of carbon dioxide equivalent (Gt CO^2e) on an annual basis by 2070, more than seven times the estimated climate-safe threshold of 0.25 Gt CO^2e. This would produce 44.55 Gt CO^2e of cumulative excess emissions through to 2070, equivalent to about 16 years of India’s energy-related CO^2 emissions (at 2023 levels). This underscores the scale of the long-term climate risk embedded in current consumption and production trends.

Conversely, production-side mitigation would reduce emissions to 0.73 Gt CO^2e by 2070, lowering cumulative excess emissions to 20.66 Gt CO^2e. Protein demand diversification plays a central role in this transition, supporting both climate mitigation and long-term protein security. Under the demand diversification pathway, which builds on the production mitigation scenario, annual emissions decline further to 0.50 Gt CO^2e at 2070, while cumulative excess emissions to 2070 fall to 12.90 Gt CO^2e above the climate-safe threshold.

This pathway reflects the additional emissions-reduction potential of progressively substituting a share of conventional animal protein demand

with emerging alternative proteins, alongside continued growth in traditional plant proteins such as pulses and legumes. In India, this builds on an existing foundation of culturally familiar plant proteins, while emerging pathways in plant-based, fermentation-derived, and cultivated proteins could further expand the diversification opportunity, supported by initiatives such as BioE3 and India's growing manufacturing ecosystem.

These pathways could deliver significant resource efficiencies. Product lifecycle assessments indicate that plant-based proteins can reduce greenhouse gas emissions by 46–99%, land use by 79–96%, and water use by up to 95%, compared with heavily fossil fuel-dependent conventional animal protein systems. Our analysis suggests that the strongest outcomes emerge when production-side mitigation is combined with diversified protein demand growth.

Under the integrated pathway — where efficiency gains across dairy, poultry and seafood systems occur alongside greater uptake of pulses, traditional plant proteins, and emerging alternatives — annual emissions fall to 0.30 Gt CO^2e at 2070. While this remains above the estimated climate-safe threshold of 0.25 Gt CO^2e, it materially narrows the gap and reduces cumulative excess emissions through 2070 to 8.37 Gt CO^2e.

The transition must also be just. Dairy currently remains smallholder-led, poultry and fisheries rely on contracted or fragmented producer networks, and many transition costs could be pushed upstream onto farmers, contract growers, and MSMEs. Without consultation, targeted finance, procurement reform, technical assistance, and producer support, sustainability requirements could risk smallholder and supply chain resilience.

For companies, investors, banks, and policymakers, the message is clear; India's protein transition is not a niche sustainability issue but a material economic, climate, and food security challenge and imperative.

RECOMMENDATIONS

To stay within climate limits and deliver nutrition security, companies, investors, financial institutions and policymakers must act decisively this decade.

1. Prioritise high-impact production-side mitigation.	Accelerate emission reductions across the livestock value chain—land use and deforestation, methane from enteric fermentation and manure, feed efficiency, and loss and waste reduction.
2. Build a more resilient and responsible dairy system.	Invest in productivity, animal health and welfare, climate-resilient feed, water stewardship and smallholder support to strengthen India's largest protein source while reducing emissions intensity.
3. Scale pulses and traditional plant proteins.	Expand cultivation, processing and market access for pulses and other traditional plant proteins through procurement commitments, processing capacity, and innovation in ingredients and convenience foods.
4. Build pathways for emerging proteins.	Support R&D, pilot-to-scale manufacturing and enabling infrastructure for alternative proteins, including fermentation and cultivated proteins, to diversify supply and reduce long-term emissions risk.
5. Strengthen transparency, traceability and risk management.	Improve traceability, adopt robust animal welfare and AMR stewardship practices, and integrate protein-related metrics into disclosures and due diligence to manage climate, nature and social risks.
6. Mobilise capital and partnerships for transition.	Direct capital and blended finance towards climate-smart crops and feed innovation, cold-chain infrastructure, pulse processing, alternative protein manufacturing, smallholder transition support and animal health systems.

"For companies, investors, banks, and policymakers, the message is clear; India's protein transition is not a niche sustainability issue but a material economic, climate and food security imperative."

A resilient pathway will require climate and resource-efficient production improvements, mainstream protein diversification, stronger safeguards on nature, traceability, livelihoods, human and animal health and welfare, and capital allocation toward future-fit supply chains.

India enters this transition with several enabling conditions: headroom for more efficient dairy systems, an established consumption base for pulses and plant-based proteins, growing biotechnology capabilities, emerging policy support through initiatives such as BioE3 and the Mission for Aatmanirbharta in Pulses, and the opportunity to shape future infrastructure before high-emissions dependencies become further locked in.

This report identifies six priority actions for companies, investors, financial institutions, and public agencies seeking to support a more resilient protein transition in India.

Introduction

Why India’s Protein System Matters Now

Our modelling projects annual per-capita protein consumption to rise sharply from a low base of 9.5kg in 2025 to 30kg by 2070. That would exceed the reference levels of EAT Lancet’s science-based Planetary Health Diet, even as large sections of India’s population continue to face protein insecurity. This growth will fundamentally reshape and intensify India’s food systems.

In principle, rising protein consumption is necessary. Persistent malnutrition, stunting, and dietary inequality remain significant issues in India. Improving protein access therefore remains central to the country’s development agenda, and public food system policies and laws increasingly reflect this priority. The National Food Security Act (NFSA 2013) led to one of the largest food-transfer expansions in history, covering more than 500 million people, while India’s Public Distribution System, the world’s largest food transfer programme, operates through a network of more than 500,000 fair-price shops.

Recent research found that expanded access to subsidised staples reduced household food expenditure pressures, enabling families to redirect spending toward more nutrient-dense foods such as milk, meat, fruits, and vegetables. The resulting improvement in dietary diversity is estimated to have prevented stunting in approximately 1.8 million children.

However, the additional protein demand India faces in the coming decades is on an unprecedented scale. At the same time, the structure of India’s protein system makes it uniquely exposed to a set of interlinked material risks, five of which stand out:

- **climate and emissions impact, and also vulnerability**
- **feed, water, and resource constraints**
- **public health, animal health and welfare, and food safety risks**
- **livelihood and transition risks**
- **policy and market transition risks**

1. The system is increasingly vulnerable to climate-related pressures, while simultaneously driving climate change. Livestock production is a major source of emissions within India’s food system. Agriculture contributes around 14% of India’s greenhouse gas emissions, with livestock responsible for more than half of that share.

If demand rises unabated, our modelling projects annual emissions from India’s protein system to reach 1.92 Gt CO^2e by 2070 under a BAU pathway — more than seven times the 0.25 Gt CO^2e climate-safe threshold used in this report (defined as the annual emissions level required to keep India’s food systems within a 1.5°C-compatible global carbon budget). Through 2070, this BAU pathway would generate approximately 44.55 Gt CO^2e of cumulative excess emissions above that threshold.

2. The system is increasingly vulnerable to inefficiency pressures. For instance, feed systems represent a critical source of risk. Intensive animal protein production depends heavily (and inefficiently) on feed inputs, which are subject to climate impacts, price volatility, land constraints, and, in some cases, import dependencies and deforestation risk.

In the dairy sector, feed and fodder availability already constrain productivity and profitability at the farm level, with India facing an estimated 35.6% shortfall in green fodder, 10.5% shortfall in dry fodder, and a 44% deficit in concentrate feed ingredients. These pressures are likely to intensify as climate change disrupts domestic feed production. Government projections suggest wheat yields could decline by 19.3% by 2050, while kharif maize yields — an important input for India's poultry sector — could fall by up to 23%, further increasing feed volatility and producers' input costs.

In poultry, feed accounts for the majority of production costs and the sector is heavily reliant on maize and soybean meal. Approximately 47% of India's maize production is already used for poultry feed, with maize accounting for nearly 60% of poultry feed formulations. At the same time, maize demand from India's ethanol blending programme is projected to rise from 7 million tonnes in 2024/25 to 9 million tonnes in 2025/26, creating growing competition for feed inputs.

As demand for animal protein increases, pressure on feed systems is likely to intensify, with implications for farmer access, profitability, food inflation, and environmental sustainability. These pressures extend beyond feed markets. Many regions of India already face significant water stress, and livestock production, particularly dairy, can be even more resource-intensive when upstream feed production is taken into account.

According to the National Dairy Development Board, approximately 30% of agricultural water use in India is directed toward livestock. Expanding production without corresponding improvements in efficiency and resource management, along with protein diversification, could exacerbate these pressures, creating risks for long-term supply security.

3. Public health, animal health and welfare, and food safety concerns are becoming more salient. The use of antibiotics in animal agriculture, particularly in aquaculture, poultry and dairy systems, raises concerns around antibiotic residues and antimicrobial resistance (AMR), which is increasingly recognised as a major global health risk. India already faces one of the world's highest AMR burdens, which is linked in part to the widespread and often routine use of antibiotics in livestock and aquaculture systems. In parallel, issues such as traceability, contamination, and product quality are becoming more important to consumers, regulators, and institutional buyers. Poor animal welfare further compounds this issue, contributing to lower immunity, greater disease and infection risks. These concerns already impact trade, and are likely to shape future regulatory frameworks and market expectations.

4. India's protein system is closely linked to livelihoods and rural economies. Millions of smallholder farmers depend on livestock as a source of income and economic stability. In dairy, for instance, smallholder farms currently account for about 72% of national milk production, underscoring the sector's deep integration with rural livelihoods. In poultry, organised contract farming accounts for an estimated 80% of production value, reflecting the growing role of integrators and vertically coordinated supply chains, although much of this production still relies on networks of small and medium-scale growers. More broadly, livestock contributes around 16% of farm income and supports the livelihoods of millions, particularly small and marginal households.

Any transition in the protein system must therefore be compatible with livelihood security and inclusive growth. This makes the transition challenge more complex, as some pathways that may be accelerated in more industrialised markets may not be applicable to India.

5. The policy and market landscape is evolving. Government nutrition programmes are increasingly reinforcing protein demand as part of broader human capital goals. Mission POSHAN 2.0 explicitly links nutrition outcomes to long-term productivity and human development, while its supplementary nutrition guidelines increasingly emphasise diet diversity, protein quality, and micronutrient adequacy. The programme now reaches nearly 1.4 million Anganwadi centres and approximately 90 million beneficiaries, reflecting the scale at which nutrition policy is shaping future food demand.

At the same time, regulatory frameworks related to sustainability, disclosure, and food safety are beginning to take shape. The Securities and Exchange Board of India's Business Responsibility and Sustainability Reporting framework now applies to the country's top 1,000 listed companies, signalling a broader shift toward more robust ESG disclosure, including climate-related reporting. Financial institutions and investors are also starting to assess climate and sustainability risks more systematically, including in food and agriculture sectors. Industry estimates suggest that more than 60% of Indian agribusinesses were expected to adopt basic/minimal ESG standards by 2025, although protein-related metrics remain largely absent from current disclosure frameworks.

Taken together, these dynamics indicate that India's protein system is not only growing but also becoming more complex, more resource-intensive, and more exposed to a range of systemic risks. Without a shift in how this demand is met, these risks are likely to intensify, locking in growing exposure for companies, financial institutions, and policymakers. The challenge is not to limit protein consumption but to ensure that future growth is aligned with climate goals, resource constraints, public health and welfare priorities, and economic resilience.

About Charting India's Protein Transition

The original 2023 modelling has been changed to reflect updated datasets, deeper India-specific analysis, more market specific protein diversification, and wider consultation with food-system and thematic experts. The report retains the same core scenario framework used in the 2023 analysis (see *Executive Summary*) but better incorporates the existing traditional plant-protein basis. Drawing on parameters from the SBTi's *Food, Land and Agriculture Guidance* (2022), the analysis explores how different pathways could improve the environmental performance and resilience of India's protein system. The report refers to this broader shift toward a more responsible, diversified and sustainable protein system as the protein transition.

Methodology

For this report, the BAU analysis from [Charting Asia's Protein Transition] (ARE, 2023) was updated and expanded to model India's protein system through 2070. The analysis combines projected demand growth across major protein categories with assumptions around emissions intensity, production-side mitigation measures, and protein diversification pathways.

Starting with ambitious assumptions for how supply-side mitigation measures could reduce emissions from dairy, poultry, seafood, and other animal protein production systems, we then assessed the additional emissions-reduction potential of greater demand diversification, including traditional plant-based proteins and emerging alternative proteins.

To assess climate alignment, the modelling adapts relevant elements of the SBTi *Food Land and Agriculture* (2022) guidance to the Indian context and benchmarks outcomes against an estimated climate-safe threshold for food-system emissions. The analysis also uses the EAT-Lancet Commission's *Planetary Health Diet* (2019) as a directional reference point for understanding protein diversification, dietary patterns, and broader system-level implications for emissions and resource use.

Further, this analysis adopts an India consumer demand-driven approach, where shifts in dietary consumption driven by rising incomes and a growing population are translated into corresponding production and emissions outcomes. Within this model, export-oriented sectors are noted as important contextual features of India's total protein economy rather than primary drivers of projected local demand.

Accordingly, the report's demand and emissions scenarios are primarily based on projected domestic consumption trends. While export-oriented production is significant, particularly in seafood, it is not modelled in future demand scenarios unless otherwise specified. Detailed scenario assumptions and pathway definitions are set out in the following sections.

Scope

Market: This analysis focuses on consumption-driven protein production within India. Export-oriented production is excluded, while imported processed protein products, including whey and other dairy-derived protein ingredients produced outside India, are not separately modelled. The analysis therefore does not represent the full consumption-based emissions footprint of all protein products consumed in India. The exclusion of export-oriented production also means that the findings are likely to underestimate total protein-related emissions from production at the national level.

Protein types: We include dairy and eggs, mutton, pork, poultry, and seafood (both wild-caught and farmed) in our model, along with traditional plant-based protein sources and a range of alternative proteins expected to become commercially available over time.

Time horizon: The modelling time horizon extends to 2070, aligning with India's Net Zero commitment under its Nationally Determined Contribution, while recognising that food and agriculture are hard-to-abate sectors likely to require continued mitigation beyond 2050. While the SBTi typically uses a 2050 endpoint, extending the timeline enables a more realistic representation of sectoral transition pathways in the Indian context.

For land-use assumptions, we have adopted a 2030 zero-deforestation target year, aligning with global commitments on deforestation and biodiversity. Energy-related emissions are aligned with a 2070 net-zero trajectory.

Mitigation assumptions across key emission sources include a 70% reduction in enteric fermentation, manure management, and feed-related emissions by 2070, reflecting combined technological and management improvements. In parallel, food loss and waste are reduced by 30% by 2035. All percentage reduction targets use 2025 as the baseline year.

While these assumptions broadly align with the mitigation framework used in *Charting Asia's Protein Transition*, selected parameters are adapted to reflect modelling requirements, technological advancements since, and India-specific transition dynamics.

Impact: India's expanding protein production has a range of other negative environmental effects, including biodiversity loss, pollution, water scarcity, and soil degradation, as well as concerns around animal welfare, antibiotic-resistant bacteria, and infectious diseases. This report, however, confines its discussion to mitigating greenhouse gas emissions, while also accounting for the impact of land-use change, particularly deforestation, within its analysis.

Science-Based Modelling

This analysis combines the latest available empirical and projected data on protein consumption, population demographics, and science-based greenhouse gas emissions intensities. The main databases used are from intergovernmental sources, including the Food and Agriculture Organization of the United Nations (FAO), the Organisation for Economic Co-operation and Development, the World Bank, and the United Nations Population Division. These inputs were supplemented with India-specific government and sectoral datasets, where relevant. Together, they are used to assess how consumption-driven animal protein production may evolve over time, and to identify the scale of mitigation and diversification required to align the sector with climate-safe emissions levels.

The modelling broadly follows the steps below:

1. Establishing the BAU consumption and emissions pathway: We first modelled historical and projected consumption trends for the relevant animal and traditional plant proteins. This was based on observed empirical consumption data and demographic projections, which together form the basis of the BAU scenario. The BAU scenario therefore reflects how protein demand may evolve if current consumption patterns continue in line with expected demographic changes.

For this analysis, we assumed that future increases in conventional animal protein demand would be primarily met through domestic production, rather than imports. We then estimated protein-related emissions associated with projected consumption under the BAU scenario using the latest FAO Global Livestock Environmental Assessment Model (GLEAM) datasets and emissions intensity values by animal protein type. The BAU scenario assumes continued overall productivity improvements at a rate of 1% per year, which reduces overall emissions intensities over time. However, it does not assume the implementation of major additional supply-side mitigation measures.

Projected BAU emissions were then compared against a climate-safe emissions level adapted from the SBTi's Forest, Land and Agriculture pathway. This comparison is presented in terms of both annual and cumulative excess emissions through to 2070. As the analysis develops different transition pathways to estimate the mitigation potential of various measures, projected emissions under each pathway are compared against the same India specific climate-safe threshold.

2. Production-side Mitigation Pathway: Next, we modelled a Production-side Mitigation Pathway by estimating the potential reduction in emissions intensity from the best-case application of supply-side interventions across animal protein systems. This pathway is equivalent to what has previously been described as a "Best-Case Mitigation" scenario.

The supply-side interventions considered span enteric fermentation, feed production, energy consumption, and food loss and waste. The assumed pace and extent of mitigation across these areas are explored further in the *Results* section.

3. Incorporating a level of demand diversification: Where emissions under the Production-side Mitigation Pathway remained above the climate-safe level, we modelled the emissions-reduction potential of demand diversification in which traditional plant proteins continue to grow along the BAU trajectory, alongside progressive substitution of conventional animal protein demand with emerging alternative proteins. This formed the Demand Diversification Pathway.

In this context, diversification refers to the proportion of conventional animal proteins that are replaced by alternative proteins. This does not affect the projected consumption levels of traditional plant proteins.

4. Assessing an Integrated Transition Pathway: Finally, we modelled an "Integrated Transition Pathway", which builds on the Demand Diversification Pathway by incorporating two further demand-side mitigation measures: first, increasing the consumption of traditional plant proteins and, second, capping total protein consumption at healthy and sustainable levels in line with EAT-Lancet Commission recommendations.

This pathway builds on the Demand Diversification Pathway by first increasing the consumption of traditional plant proteins, including pulses, legumes, and other culturally familiar plant-based protein sources. This reflects India's existing dietary foundation and the potential to strengthen protein security through lower-emissions protein sources that are already widely consumed and socially accepted.

Second, the pathway applies a long-term protein consumption cap aligned with healthy and sustainable dietary levels, using the EAT-Lancet Commission's Planetary Health Diet as a directional reference. It is applied as a system-level modelling parameter to test how future demand could remain within healthier and more sustainable boundaries.

Results

To gauge whether projected growth in protein consumption remains within sustainable limits, we assessed data against the EAT-Lancet Commission's Planetary Health Diet (PHD) reference framework and an estimated climate-safe threshold for all food-system emissions in India.

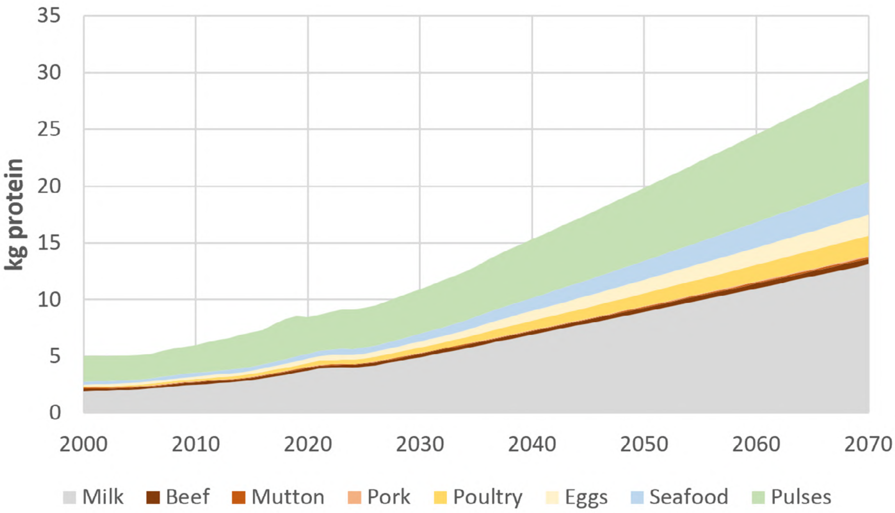
Given India's unique context – marked by persistent nutrition gaps, affordability constraints, and diverse dietary practices – the focus of this analysis is not on limiting protein consumption but on understanding how future protein demand can be met in ways that remain compatible with climate, resource, and food-system resilience objectives. This includes strengthening the role of pulses and traditional plant proteins, while supporting balanced growth across dairy, poultry, seafood, and emerging alternative proteins in a manner that aligns with nutritional needs, access and environmental limits.

Toward 2070: India's Protein Transition Starts from a Different Baseline

India's protein transition begins from a fundamentally different starting point than many Western markets, where debates around food-system emissions are often based on maximum industrial production and high per-capita levels of meat consumption.

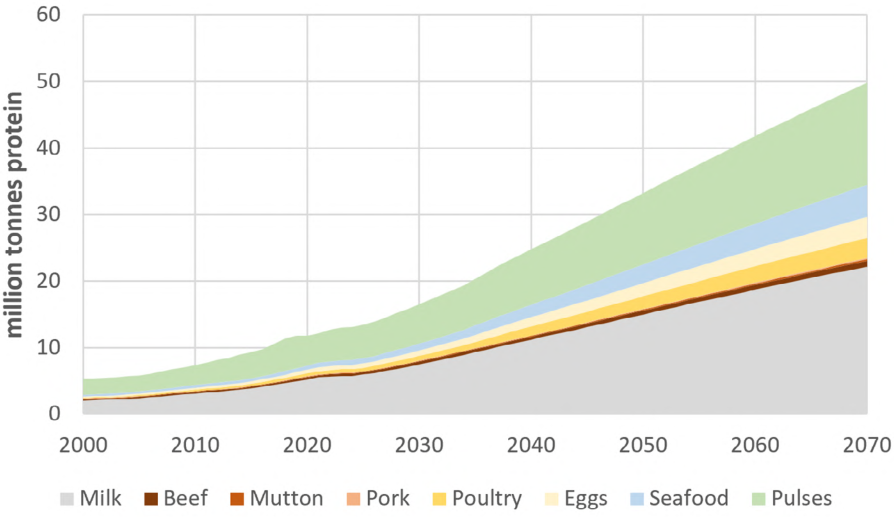
In India, protein demand remains shaped by a distinct mix of socioeconomic and nutritional realities, cultural preferences, and production structures, making simplistic transition narratives both analytically weak and politically unworkable. Empirical and projected per-capita protein consumption by source and proportion is shown in Figure 1.

Figure 1: Projected Per Capita Protein Consumption, by Source (2000–2070)



Source: ARE modelling.

Figure 2: Projected Per Capita Total Protein Consumption by Source (2000–2070)



Source: ARE modelling.

While per capita protein consumption is projected to rise significantly from 2025 to 2070, India's BAU pathway remains distinct from many higher-income and East/Southeast Asian markets. Our analysis finds that by 2070, India's protein demand is projected to remain anchored in dairy and pulses. At the same time, demand for eggs, poultry, and seafood is expected to grow steadily from a smaller base, while red meat continues to account for a relatively small share of overall consumption. The risks, production models, and transition pathways across these sectors are therefore far from uniform.

Dairy: still dominant, with implications for resilience, resources, and emissions

Dairy remains the single biggest source of animal protein in India's food system and is projected to account for the largest share of future protein growth.

According to estimates, protein consumption from milk alone will grow from less than 5 million tonnes in 2025 to 13.3 million tonnes by 2070, significantly more than poultry, eggs, or seafood (*see Figure 1*). Milk protein consumption will rise from 1.63kg per capita in 1990 to 13.1kg per capita by 2070, making dairy by far the largest protein category, pushing consumption well beyond the EAT-Lancet Commission PHD's reference benchmark for moderate dairy intake.

While pulses will become the second-largest category, increasing substantially from 2.61kg to 9.12kg per capita, and other sources will see significant growth, India's future protein systems are likely to remain heavily shaped by dairy.

Unlike many highly industrialised systems, India's dairy sector currently remains predominantly smallholder-supplied, despite increasing supply-chain consolidation. India produces approximately 248 million tonnes of

“The challenge ahead is not simply producing more milk; it is improving productivity, resilience, water, and emissions efficiency without undermining rural livelihoods...”

milk annually, most of which comes from households that own just two to three animals. The sector’s key challenges are consequently not only emissions and methane intensity but also low productivity, feed deficits, animal health and welfare constraints, and fragmented aggregation systems.

India’s dairy sector has significantly expanded output without relying solely on herd expansion. Milk production rose 63.6% over the decade through 2024, from 146.3 million tonnes in 2014–15 to 239.3 million tonnes in 2023–24, while bovine productivity increased by 27.4% between 2014 and 2022, among the highest growth rates globally.

The challenge ahead is not simply producing more milk; it is improving productivity, resilience, water, and emissions efficiency without undermining rural livelihoods.

Eggs and chicken: rapid growth, rising concentration

Eggs and poultry represent some of the country’s fastest-growing protein categories. Our modelling projects egg consumption to rise to 25.7 million tonnes by 2070, and poultry to 16.2 million tonnes. Poultry and eggs show moderate growth in India’s protein mix, rising to 1.79kg and 1.85kg of protein weight per capita by 2070, remaining broadly within the proportional ranges of the PHD, which recommends moderate intake (~29 g/day for poultry and ~13g/day for eggs) compared with other animal proteins.

Unlike dairy, however, egg and poultry production is far more commercially concentrated and vertically integrated. The growth of the poultry sector in the first two decades of the millennium was nothing short of a revolution, outpacing the "Green and White Revolution" expansion rates of cereals and dairy. According to official estimates, commercial industrial-style poultry production accounts for nearly 85% of India's total egg output, while backyard systems contribute a far smaller share.

Similar dynamics are evident in chicken meat production, where large integrators increasingly coordinate breeding, hatcheries, feed production, drug and veterinary services, for raising chickens through contract farming arrangements. In 2020, almost 80% of the value generated by India's poultry sector came from organised contract farming systems.

These sectors face a different set of risks: maize, soy, and antibiotic dependence, disease and biosecurity concerns, traceability gaps, feed price volatility, physical climate risks, and animal welfare concerns. Egg demand is also projected to continue growing, likely due to its affordability and its role in public nutrition programmes. This means India's poultry transition cannot rely on BAU demand growth, but neither can it be addressed through demand-side measures alone. It will also need to centre on improving production standards, antibiotic stewardship, welfare practices, and traceability systems.

Seafood: growing, but highly fragmented

Our analysis projects seafood-derived protein consumption to grow from 0.6 million tonnes of protein equivalent in 2025 to 2.9 million tonnes by 2070, making it one of India's faster-growing protein categories, albeit from a relatively small base. On a per-capita basis, seafood protein is forecast to rise from 0.21kg/year in 1995 to 2.58kg/year by 2070. This remains modest compared with dairy and pulses, but is broadly within the PHD fish intake range; slightly above the central ~28g/day reference level when converted into protein equivalent, but well below the upper recommended range.

Seafood should not be treated as a single category, however. India's seafood economy spans inland aquaculture, marine fisheries, shrimp exports, and local fish markets, each shaped by very different economic and environmental pressures. This diversity is becoming more pronounced as the sector grows.

India's total fish production has more than doubled over the past decade, from 9.6 million tonnes in 2013–14 to 19.5 million tonnes in 2024–25. Inland fisheries grew almost 140% during this period. Separately, seafood remains a major export sector, with shipments reaching INR62,408 crore (approximately USD7.3 billion) in 2024–25. Export-oriented shrimp continues to account for a significant share of sector growth, adding another layer of sustainability considerations around feed sourcing, disease management, traceability, and climate resilience.

These segments face very different risks, ranging from overfishing and climate volatility in marine systems to disease outbreaks, antibiotic and concentrated feed dependence, and export-market scrutiny of aquaculture product safety.

Pulses: India’s underleveraged advantage

Our analysis projects pulse-derived protein consumption to rise from 3.5 million tonnes of protein equivalent in 2025 to 9.3 million tonnes by 2070, making pulses India’s second-largest protein category, after dairy. The projections align with the PHD, which emphasises legumes as a primary protein source (~50–100g/day) in sustainable and health-oriented diets. This gives India an advantage that many global protein-transition models often overlook. The country has a deep familiarity with plant-based proteins through pulses and other legumes that feature heavily in traditional diets.

Pulses also have relevance beyond direct household consumption. Protein-rich crops such as chickpea, pea, and lentil can be processed into concentrates, isolates, and other functional ingredients used in plant-based meat and dairy and egg alternatives, creating opportunities to move up the value chain from commodity production to higher-value protein ingredients and food products. This is particularly relevant for India, which remains heavily dependent on imported protein ingredients despite being one of the world’s largest producers and consumers of pulses.

According to the Ministry of Food Processing Industries, India currently imports almost 90% of its plant protein isolates because of limited domestic extraction and processing capacity. This highlights both a supply-chain vulnerability and an opportunity for domestic value addition. As processing capacity, protein extraction technologies, and alternative protein manufacturing develops, pulses could play an increasingly important role in supporting protein security, industrial growth, and future protein innovation.

Assessing India’s Protein Transition Pathways

India’s protein transition will ultimately be shaped not just by demand growth but by whether that growth can occur within environmental limits while minimising the negative reinforcing effects of climate-related impacts. To assess this, four potential pathways for India’s protein system were modelled through 2070:

1. **A BAU pathway,** where current production and consumption trends continue essentially unmitigated;
2. **A production mitigation pathway,** where emissions intensity improves through best-case application of primarily animal production-side interventions;
3. **A demand diversification pathway,** build on Scenario 2, wherein traditional plant proteins continue to grow along the BAU trajectory, alongside progressive substitution of conventional animal protein demand with emerging alternative proteins reduces reliance on emissions-intensive animal protein growth; and
4. **An integrated transition pathway,** which builds on Scenario 3; the demand diversification pathway by additionally increasing traditional plant protein consumption and moderating long-term protein demand growth within healthier and more sustainable dietary ranges.

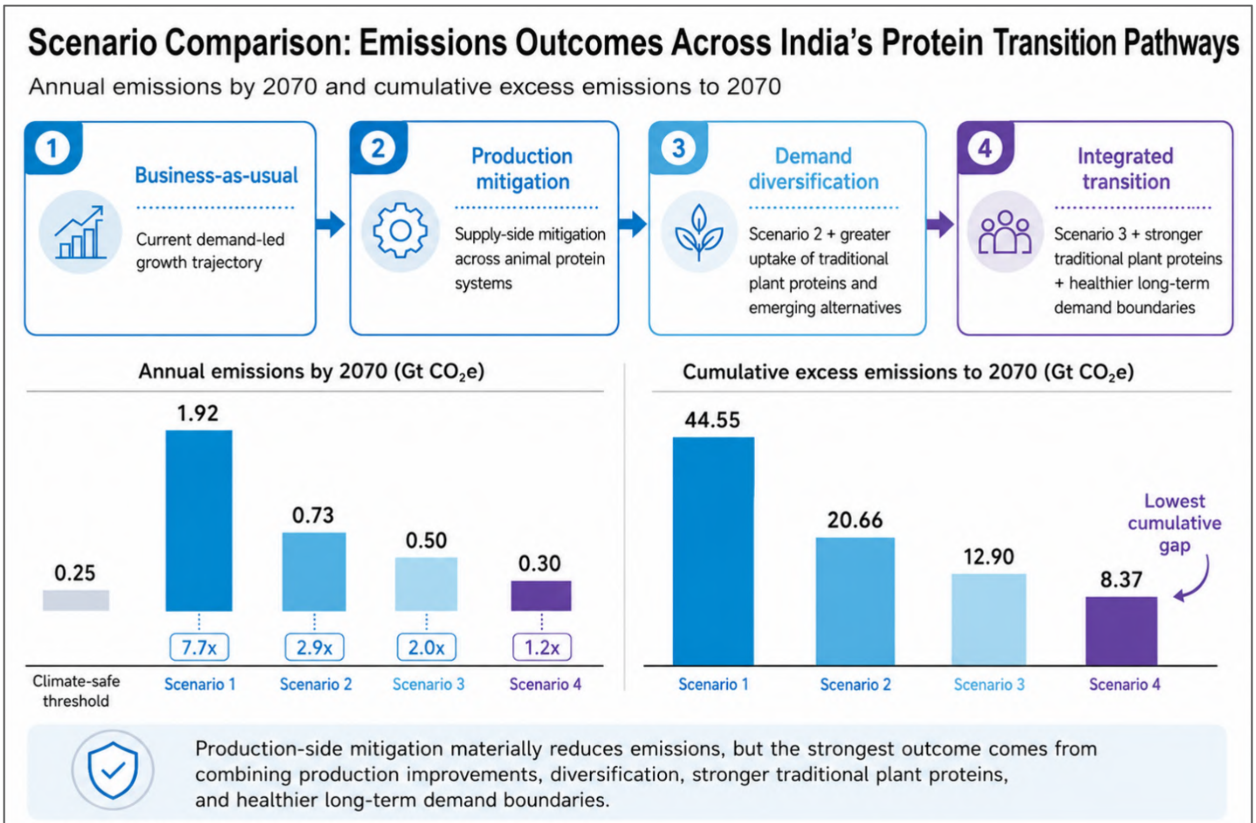
Together, these scenarios illustrate the scale of India’s protein challenge, and the limits of relying on any single intervention.

Figure 3: Scenario assumptions used in the analysis (The mitigation assumptions are modelled as additive and non-mutually exclusive, allowing multiple measures to be applied concurrently.)

Scenario 1: BAU	Continued Productivity Improvement (YoY increase through 2070)	1.0%
Scenario 2: Production Mitigation Scenario[1]	Zero-Deforestation Target Year	2030
	Net-Zero Energy Target Year	2070
	Enteric Fermentation Mitigation (% reduction by 2070)	70%
	Manure Emissions Mitigation (% reduction by 2070)	70%
	Feed Emissions Mitigation (% reduction by 2070)	70%
	Food Loss and Waste Reduction (% reduction by 2035)	30%
Scenario 3: Demand Diversification Scenario	Share of conventional animal protein demand substituted by alternative proteins by 2035 (%)	10%
	Share of conventional animal protein demand substituted by alternative proteins by 2070 (%)	35%
Scenario 4: Integrated Transition Scenario	Boost Traditional Plant Proteins (% increase through 2070)[2]	10%
	Protein Consumption Cap through 2070 (per capita per year)	18.25kg

[1]Percentage reduction targets use 2025 levels as the baseline

[2]Percentage increase use per capita BAU consumption levels as baseline

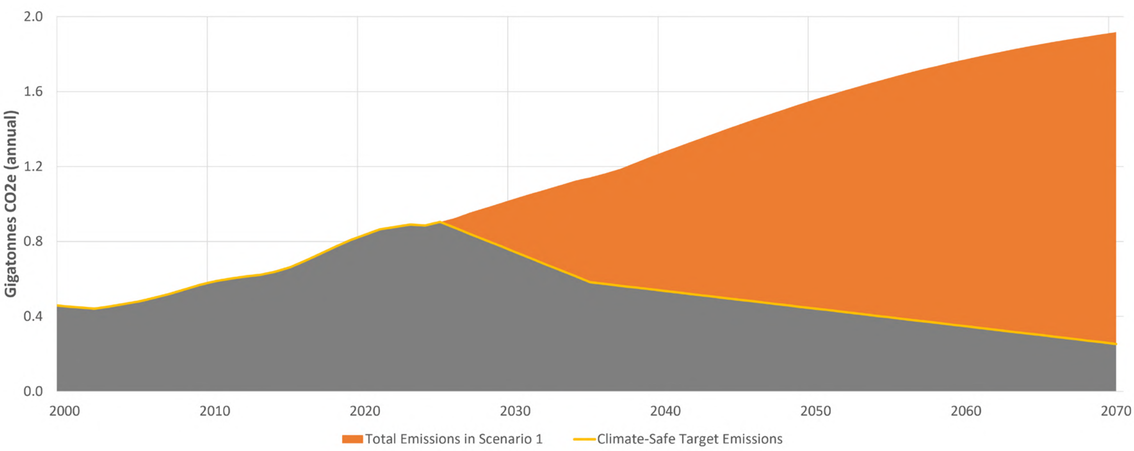


Source: ARE analysis.

Scenario 1: BAU demand growth pushes India beyond climate limits

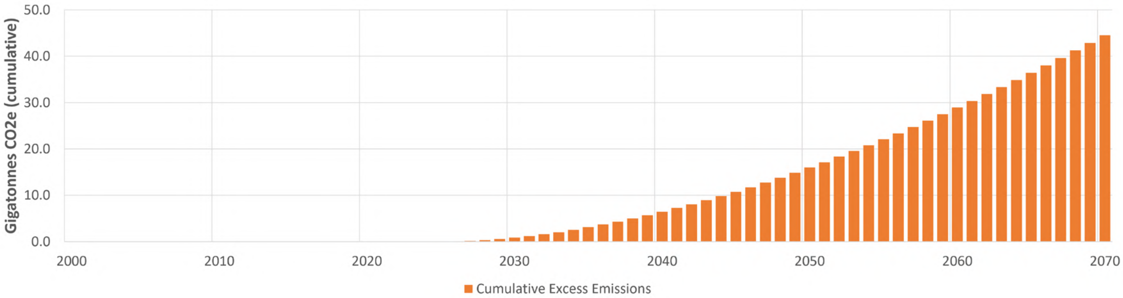
Under a BAU pathway, rising demand across dairy, poultry, seafood, and eggs significantly increases the emissions footprint of India's protein system. Our modelling projects annual protein-related emissions would rise to 1.92 Gt CO^2e at 2070 under this scenario, more than seven times the estimated annual climate-safe threshold of 0.25 Gt CO^2e, and equivalent to nearly two-thirds of India's current total annual energy-related emissions. Cumulative excess emissions to 2070 would reach approximately 44.55 Gt CO^2e above the climate-safe threshold, highlighting the enormous gap between current demand-driven pathways and climate-aligned targets.

Figure 4a: BAU emissions projections vs climate-safe threshold (2025–2070)



Source: ARE modelling.

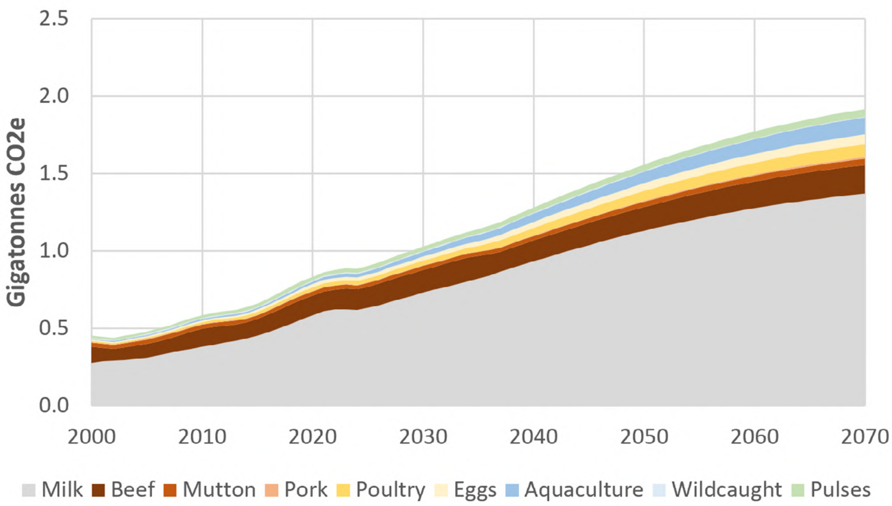
Figure 4b: BAU cumulative emissions exceeding a climate-safe threshold (2025–2070)



Source: ARE modelling.

Much of this emissions growth is driven by the continued dominance of dairy. While consumption of low-emitting pulses is projected to grow, these gains would be outweighed by emissions-intensive animal protein growth. This would push overall emissions well beyond climate-aligned thresholds to a cumulative level more than double that of China.

Figure 5: BAU total protein emissions trajectory by category (2025–2070)



Source: ARE modelling.

Scenario 2: Production-side mitigation narrows emissions, but not nearly enough

Improving how animal protein is produced remains essential. With the world's largest dairy herd, India's reductions will need to include both reduced emission intensity and a lower emissions growth rate, including a major reduction in methane.

To assess the upper range of potential reductions from supply-side measures, the report modelled an ambitious long-term mitigation pathway across dairy, poultry, and aquaculture systems. This scenario incorporates the suite of "best-case mitigation" targets set out in the methodology and detailed below.

In dairy, these measures would include higher productivity per animal,

Mitigation assumption	Basis and context
Zero-deforestation target year: 2030	The 2030 target year is used as a pragmatic modelling milestone aligned with global forest commitments, including the Glasgow Leaders' Declaration goal to halt and reverse forest loss and land degradation by 2030. It also reflects the direction of travel under supply-chain frameworks such as the Accountability Framework initiative, which emphasise clear cut-off and target dates for deforestation- and conversion-free supply chains. 2030 is adopted here as the next major global milestone from a 2025 modelling baseline.
Net-zero energy target year: 2070	The 2070 target year is aligned with India's publicly announced national net-zero emissions goal. In this analysis, the assumption applies to energy-related emissions across the protein value chain, including not only grid electricity but also non-power energy uses in production, processing, cold chains, transport, and input manufacturing. This reflects the report's broader modelling horizon to 2070.
Cross-cutting note for enteric fermentation, manure, and feed emissions assumptions below:	
The 70% reduction assumptions for enteric fermentation, manure emissions, and non-land-use-change feed emissions include the benefits of broader productivity improvements, not only direct abatement technologies within each emissions category. In dairy, this includes higher milk yield per cow through better animal health, productivity, herd management, and selective breeding. In animal protein systems, it also includes improved feed efficiency, lower feed conversion ratios, reduced mortality, and better production management, which can reduce emissions intensity per unit of protein produced.	
Enteric fermentation mitigation: 70% reduction by 2070	This assumption represents an ambitious best-case methane mitigation pathway, particularly relevant to India's dairy-heavy protein system. It reflects the potential combined impact of improved feed formulation, and methane-reducing feed additives. The 70% reduction should be interpreted as a scenario parameter for long-term mitigation potential rather than a forecast of current deployment levels.

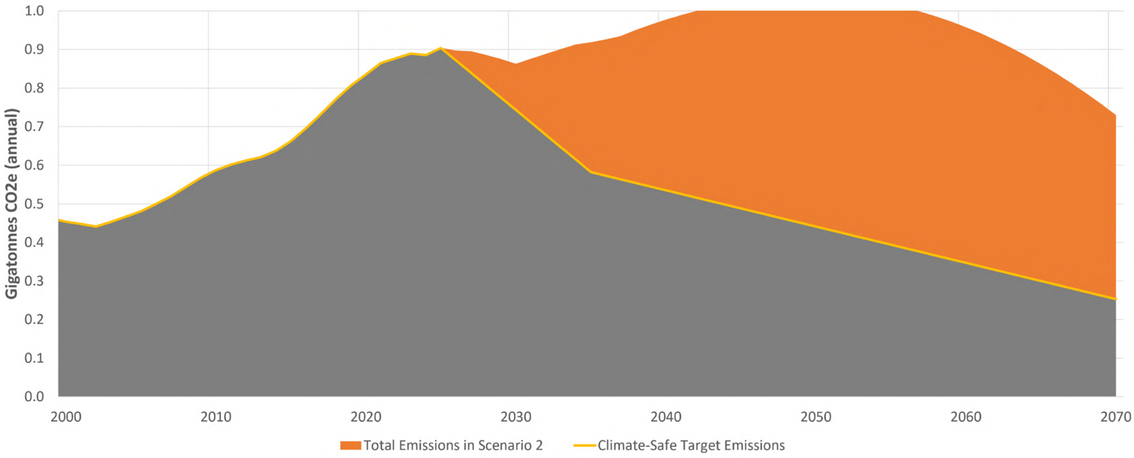
Mitigation assumption	Basis and context
Manure emissions mitigation: 70% reduction by 2070	This assumption reflects the potential for significant methane and nitrous oxide reductions through improved manure management. Relevant measures include better manure collection, covered or improved storage, composting, anaerobic digestion and biogas systems, nutrient management, and improved application of manure to land. The assumption is ambitious and depends on wider access to finance, infrastructure, technical support, and producer participation, particularly in smallholder and fragmented systems.
Feed emissions mitigation, excluding land use and land-use change: 70% reduction by 2070	This assumption covers non-land-use-change emissions associated with feed production and use. Potential reductions may come from improved feed formulations, better crop productivity, improved fertiliser efficiency, and reduced feed wastage. Land-use and deforestation-related impacts are treated separately under the zero-deforestation assumption.
Food loss and waste reduction: 30% reduction by 2035	This assumption takes reference from Sustainable Development Goal 12.3, which calls for a reduction in food losses and a halving of per-capita global food waste by 2030. However, because this analysis uses 2025 as the baseline year and focuses specifically on protein-related supply chains, a 30% reduction by 2035 is adopted as a pragmatic and still ambitious modelling assumption. Reducing loss and waste lowers emissions by reducing the level of production required to meet final consumption demand.

Mitigation lever	Cumulative emissions reduction contribution under Scenario 2, 2025–2070 (Gt CO_2e)
Zero deforestation	8.9
Enteric fermentation mitigation	8.8
Feed mitigation, excluding land use and land-use change	2.9
Net-zero energy	2.2
Manure mitigation	1.2
Total	23.9

improved feed formulation, enteric methane reduction, manure management, and stronger quality, safety, and cold-chain controls to reduce loss and waste. In poultry and aquaculture, relevant measures include improved feed conversion ratios, lower mortality, stronger disease management and biosecurity, and operational efficiencies that reduce emissions intensity per unit of protein produced. These assumptions are intentionally ambitious and should be interpreted as modelling parameters for long-term mitigation potential rather than forecasts of likely deployment.

The modelling suggests that the largest mitigation contributions within this pathway come from zero-deforestation measures, enteric methane reduction, and feed-related interventions. Together, these account for the majority of estimated emissions reductions under the production-side mitigation scenario, highlighting the central importance of land-use management, methane reduction, and feed efficiency within India's livestock systems.

Figure 6: Production mitigation pathway emissions trajectory vs climate-safe threshold (2025–2070)



Source: ARE modelling.

The modelling suggests that even highly ambitious production-side mitigation measures are insufficient on their own to align India's protein system with climate-safe pathways under continued demand growth. While the interventions modelled under this scenario materially reduce emissions relative to BAU, the remaining emissions gap remains substantial.

Under the production mitigation pathway, annual emissions fall from 1.92 Gt CO^{2}e under BAU to 0.73 Gt CO^{2}e by 2070. This represents a significant reduction, but annual emissions still remain nearly three times higher than the estimated annual climate-safe threshold of 0.25 Gt CO^{2}e. Cumulative excess emissions to 2070 remain substantial, reaching 20.66 Gt CO^{2}e above the climate-safe level.

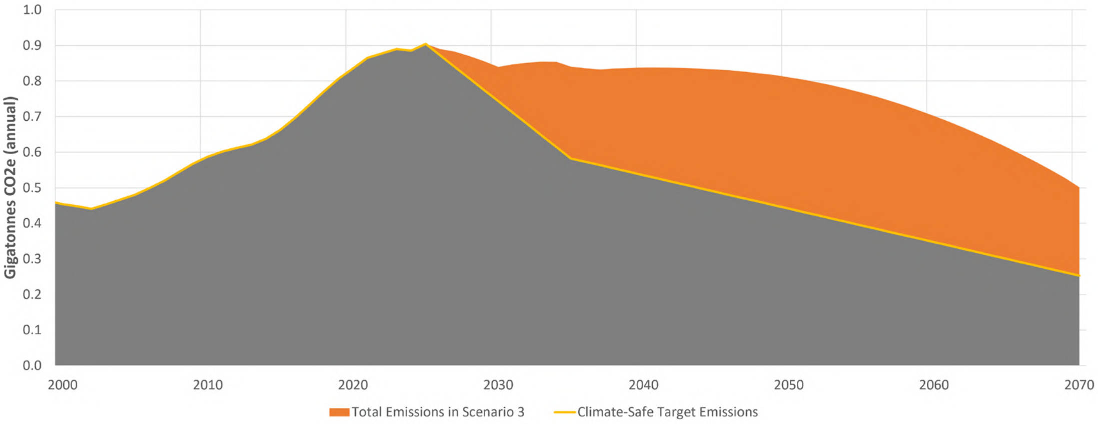
Scenario 3: Demand diversification as a key mitigation lever materially improves outcomes

India's structural advantages become particularly important under the demand diversification scenario. By modelling continued growth of traditional plant-based proteins and combining it with progressively greater substitution of conventional animal proteins by emerging alternative proteins, this pathway produces deeper emissions reductions than production-side mitigation and efficiency gains alone. Under this scenario, which builds on the production mitigation pathway, annual emissions decline further to 0.50 Gt CO^{2}e by 2070, compared with 0.73 Gt CO^{2}e under Scenario 2. Cumulative excess emissions to 2070 also fall to 12.90 Gt CO^{2}e above the climate-safe level.

This pathway may be particularly relevant in India, where pulses and other plant-based proteins already have an established consumption base and relatively developed supply chains. Emerging policy support — including initiatives such as BioE3 — could further strengthen the ecosystem for next-generation proteins, although challenges around affordability, infrastructure, and commercial scale are likely to remain important constraints.

To align protein consumption with sustainable and climate safe levels, a

Figure 7: Demand Diversification Mitigation Pathway Emissions Trajectory vs climate-safe threshold (2025–2070)



Source: ARE modelling.

gradual but significant shift in demand patterns toward alternative and more traditional plant-based proteins, alongside continued growth in traditional plant-based proteins, is required. This scenario assumes that alternative proteins substitute approximately 10% of conventional animal protein demand by 2035, rising to 35% by 2070, representing an ambitious long-term diversification pathway driven by increased market maturity, technological advancement, and expanded consumer adoption.

In parallel, traditional plant-based proteins continue to grow in line with the BAU trajectory, building on India's existing dietary base. Pulses, in particular, play a critical role in this transition, offering an affordable, nutrient-dense source of protein with strong climate resilience and deep cultural familiarity.

Pulses are a key pillar of sustainable, nutrient-rich, and affordable diets. Many pulse crops are well adapted to arid and low-rainfall conditions while also contributing to soil health through nitrogen fixation. Their climate resilience and long shelf life further strengthens their role in food security.

The resilience of pulses reinforces the case for plant-based proteins, which typically have significantly lower emissions than animal-based sources. GFI-commissioned life-cycle assessments of more than 30 commercial plant-based products indicate that plant-based meat can substantially reduce emissions, land use, and water use relative to conventional animal proteins, highlighting the potential for diversified protein systems to deliver environmental benefits alongside greater food security.

Policy support, including initiatives such as the Mission for Aatmanirbharta in Pulses (2025–26 to 2030–31), is likely to further strengthen domestic production and consumption, reinforcing the enabling role of plant-based proteins in a diversified food system.

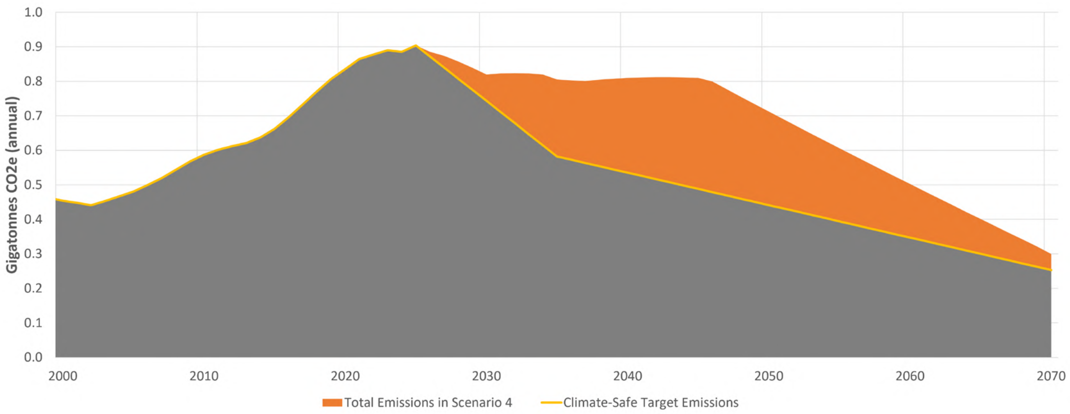
This reinforces existing technical analyses that show diversification is not a peripheral climate strategy but one of the most important levers for cutting emissions and reducing pressure on land, water, feed, and supply chains, and therefore an essential component in long-term resilience.

Scenario 4: Integrated transition pathways deliver the strongest outcomes

The strongest emissions outcomes occur when production-side improvements are combined with diversified protein demand growth and healthier long-term demand boundaries. The integrated transition pathway builds on the demand diversification pathway by combining efficiency gains across dairy, poultry, and seafood systems alongside greater uptake of pulses, traditional plant proteins, and emerging alternatives, while simultaneously moderating long-term protein demand growth within healthier and more sustainable dietary ranges.

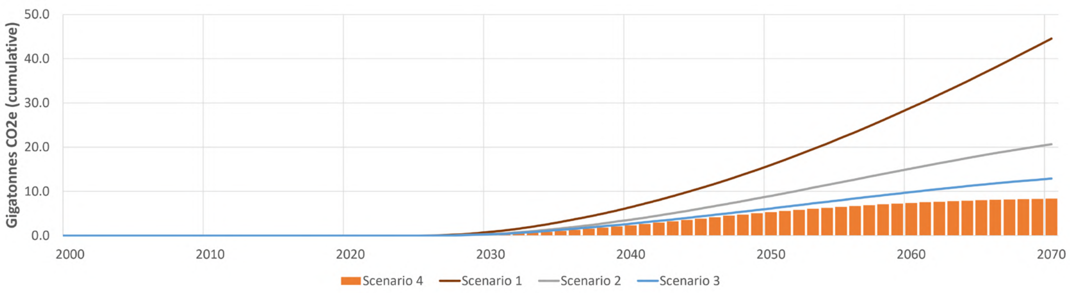
Under this scenario, annual emissions fall to 0.3 Gt CO^{2}e at 2070. This brings India significantly closer to the estimated annual climate-safe threshold of 0.25 Gt CO^{2}e, while cumulative excess emissions to 2070 fall to 8.37 Gt CO^{2}e above the climate-safe level.

Figure 8: Integrated mitigation pathway projection emissions vs climate-safe threshold (2025–2070)



Source: ARE modelling.

Figure 9: Cumulative excess emissions in all four scenarios



Source: ARE modelling.

The modelling indicates that no single intervention pathway is likely to be sufficient on its own. Production-side mitigation narrows emissions growth but does not adequately offset rising demand, while diversification pathways become more effective when paired with improvements in existing animal protein systems. Together, these pathways substantially improve India's ability to meet future protein demand while reducing dependence on emissions-intensive growth trajectories. In short, the final combined scenario enables a protein secure and climate-safe system.

Figure 10: Annual and cumulative emissions outcomes across the modelled protein transition pathways, 2025–2070

Scenario pathway (2070)	Emissions in 2070 (Gt CO_2e)	Relative to climate-safe threshold (0.25 Gt CO_2e)	Cumulative excess emissions (Gt CO_2e)
Climate-safe threshold	0.25	—	—
Business-as-usual Pathway	1.92	7.7x	44.6
Production-side Mitigation Pathway	0.73	2.9x	20.7
Demand Diversification Pathway	0.5	2.0x	12.9
Integrated Transition Pathway	0.3	1.2x	8.4

Even under this scenario, the margin for delayed or incomplete adoption remains narrow. The longer that transitions are postponed, the greater the emissions and other impacts, along with the risk of more abrupt, disruptive, and economically costly adjustments later.

Taken together, the modelling highlights both the scale of India’s protein transition challenge and the limits of relying on any single intervention pathway. The table below compares the emissions outcomes across the four modelled pathways in 2070 relative to the estimated climate-safe threshold aligned with a 1.5°C-compatible global food-system carbon budget.

The relative distance from the climate-safe threshold illustrates the limits of incremental change. While production-side mitigation materially improves outcomes, emissions under this pathway still remain 2.9-times higher than the estimated annual climate-safe threshold by 2070. Demand diversification performs significantly better, reducing annual emissions to two-times the threshold. The integrated transition pathway delivers the strongest outcome, reducing annual emissions to 0.30 Gt CO^2e, or 1.2-times the threshold.

The difference between Scenarios 3 and 4 highlights the additional mitigation value of pairing diversification with stronger traditional plant-protein consumption and healthier long-term demand boundaries.

Discussion

Interpreting the findings in context

The findings broadly align with a growing body of global research suggesting that production-side mitigation alone is unlikely to fully align food systems with climate-safe pathways under continued demand growth. Similar conclusions emerge from the World Bank's *Recipe for a Liveable Planet: Achieving Net Zero Emissions in the Agrifood System* (2024), FAIRR Initiative's *Shifting Diets: A Market Opportunity to Abate Climate, Nature and Health Risks* (2024), and the EAT-Lancet Commission's *Healthy, Sustainable and Just Food Systems* (2025), all of which highlight the importance of combining productivity improvements with protein diversification and broader demand-side shifts to achieve food-system sustainability goals.

India's protein transition, however, differs materially from higher-income markets where per-capita meat consumption is already significantly above global dietary benchmarks. India continues to face widespread protein insecurity, affordability constraints, and strong dependence on livestock-linked livelihoods — particularly dairy. The challenge is managing future protein demand growth in ways that improve nutrition security while avoiding lock-in to highly emissions-intensive pathways.

Diversification pathways should not, however, be treated as automatically scalable and commercially available at a single time point. GFI India's *2026 State of the Industry* reports note that plant-based, cultivated, and fermentation-derived proteins are continuing to evolve and innovate, while at the same time facing constraints related to price competitiveness, infrastructure, regulatory pathways, funding conditions, and process validation.

India's protein transition is therefore unlikely to follow a single pathway. Our modelling suggests that production-side mitigation and demand diversification are both essential, but the strongest outcomes emerge when these are combined with stronger traditional plant-protein pathways and healthier long-term demand boundaries.

The implication is not that one intervention can "solve" the transition.

“Even under highly ambitious mitigation and diversification pathways, India’s protein system does not fully close the gap to climate-safe emissions levels, although the integrated pathway brings it substantially closer.”

Rather, India’s protein system will require coordinated action across production efficiency, protein diversification, resource resilience, market standards, finance, and producer support. The integrated transition pathway materially reduces the long-term emissions gap, but continued action will still be needed to manage residual climate, livelihood, health, and market risks.

The cost of inaction is likely to rise

The cost of inaction or delay will not be evenly distributed. Our modelling suggests that even under highly ambitious mitigation and diversification pathways, India’s protein system does not fully close the gap to climate-safe emissions levels, although the integrated transition pathway brings it substantially closer.

This reflects the scale of the structural challenge India faces in feeding a population projected to rise to approximately 1.52 billion by 2030 and 1.7 billion by 2050 while simultaneously addressing persistent protein insecurity, rising incomes, urbanisation, dietary diversification, and growing demand for animal-source foods and processed protein products.

Importantly, the analysis assumes that future growth in protein demand is primarily met through domestic consumption and does not fully account for additional emissions associated with export growth, meaning future emissions pressures are likely to be higher than modelled here.

The scenario results point to a clear hierarchy of action. Production-side mitigation is essential, particularly for dairy methane, feed systems, land-use risk, manure management, and loss plus waste, but it cannot carry the transition alone. Demand diversification materially improves outcomes by reducing pressure on emissions-intensive animal-protein growth, while the integrated transition pathway shows that the strongest results come from combining production improvements, diversification, stronger traditional plant-protein pathways, and healthier long-term demand boundaries. The implication is that India’s protein transition requires coordinated shifts across production practices, procurement, finance, infrastructure, innovation, and demand formation.

Food companies with exposure to dairy, poultry, seafood, and processed food value chains are therefore likely to face growing operational, financial, and supply-chain pressures linked to feed crop decline, price volatility, antibiotic scrutiny, water stress, supply disruptions, and rising traceability expectations. Export-oriented seafood producers (generating additional emissions and impacts) may face additional pressure as international buyers tighten standards on residues, traceability, labour scrutiny, and environmental performance.

For investors and banks, the risk is that capital continues to support systems exposed to climate, resource, regulatory, and supply-chain risks that may not yet be fully reflected in lending decisions, investment valuations, or risk models. For policymakers and regulators, delayed action increases the likelihood of locking in production systems that become harder to abate and more expensive to reform, potentially undermining nutritional policy and worsening protein insecurity.

Efficiency gains cannot come at the expense of small producers

Production-side improvements are often presented as low-friction solutions. In practice, many of these interventions require upfront investment in better feed systems, animal genetics and health, infrastructure, loss and waste management, traceability systems, and technical training. In India, those costs are often borne by the least resourced and resilient actors in the value chain. Dairy production remains dominated by smallholders operating with two to three animals, while poultry supply chains rely heavily on contract growers and smaller operators working on thin margins. In fisheries, smaller producers often face rising compliance expectations without equivalent access to capital or technical support.

At the same time, downstream markets are becoming increasingly concentrated among large processors, retailers, exporters, and food-service companies that benefit from low-cost supply chains, while often facing limited incentives to absorb transition costs. Without financing targeted at smallholders, procurement reform, and stronger producer support systems, sustainability requirements risk becoming another cost pushed upstream onto farmers and MSMEs. A resilient protein transition will therefore require not only technological improvements but mechanisms that ensure the process is just: consultation, costs, re-skilling, incentives, access and benefits distributed equitably across the value chain.

Limits and assumptions of the analysis

The consumption-driven production modelling presented in this report should be interpreted as an illustrative scenario analysis, rather than a forecast or feasibility assessment. The scenarios are primarily based on empirical data and trends, projected domestic protein demand patterns and broad mitigation assumptions across production systems, diversification pathways, and technology uptake. Actual transition pathways will depend on a range of real-world factors not fully modelled here, including policy choices, export dynamics, infrastructure constraints, capital access and allocation, corporate and consumer behaviour, technology costs, and implementation capacity.

The analysis does not separately account for emissions embodied in imported processed protein products, where production occurs outside India.

Uncertainty also remains around the pace at which emerging alternative proteins can achieve commercial scale, affordability, and widespread adoption in India. Similarly, future productivity gains in dairy, poultry, and aquaculture systems may vary significantly depending on growing climate impacts, feed availability, water stress, disease outbreaks, and investment in farmer support systems. The scenarios should therefore be understood as directional pathways that help illustrate the relative implications of different transition strategies, rather than precise projections of future emissions.

A narrower transition window, and a larger opportunity

India's transition window is narrower than that of many developed and Asian markets because protein demand is on average still in deficit and rising very rapidly. But India also retains structural advantages many developed economies lack: deep familiarity with plant proteins, significant dairy productivity and mitigation headroom, growing biotechnology capabilities, and the ability to shape future infrastructure before excessive animal protein consumption, emissions, and system inefficiencies become locked in and even harder to abate.

India enters this transition with a number of other enabling conditions. Pulses and other legumes are already deeply embedded in diets, while recent policy initiatives such as the Mission for Aatmanirbharta in Pulses and BioE3 signal growing support for both traditional and next-generation protein systems. These developments do not guarantee a successful transition, but they provide foundations that many higher-income markets lack when confronting similar food-system challenges.

This challenge sits within a broader national ambition. As India moves toward its Viksit Bharat 2047 vision of becoming a developed economy, food systems will play a critical role in determining whether growth remains resource-efficient, nutrition-secure, employment generating and climate mitigating. Transition to a more responsible and sustainable protein system should therefore be viewed not as a niche sustainability issue, but as an essential part of India's broader economic development, food security, and climate strategy.

Conclusion and Recommendations

Building a More Climate-Aligned, Resilient, and Secure System

Our modelling suggests that under a BAU pathway, protein-related emissions could rise to 1.92 Gt CO^2e at 2070, with cumulative excess emissions reaching 44.6 Gt CO^2e above the estimated climate-safe threshold. Even under highly ambitious mitigation and diversification pathways, emissions remain approximately twice the climate-safe level by 2070, highlighting the scale of the structural challenge India faces as protein demand continues to rise. Avoiding long-term lock-in to emissions-intensive pathways will therefore require earlier and more coordinated action across production systems, infrastructure, finance, policy, and protein diversification.

Current incentives remain overwhelmingly geared toward expanding and intensifying supply rather than improving long-term resilience and security. Public policy continues to prioritise industrial production growth. Private capital remains concentrated in conventional protein systems and corporate strategies often favour low-cost procurement over supply-chain resilience and sustainability. While this model helped India rapidly expand protein availability in past decades, it is increasingly clear the country is not yet prepared for the increased exposure to feed volatility, water stress, antimicrobial resistance, all exacerbated by climate impacts, unprecedented demand growth, and tightening market expectations.

Building a more climate-aligned and resilient protein system will require coordinated shifts in three areas:

1. Productivity gains must become more resource-efficient. Companies, lenders, and public agencies all have a role in supporting this shift through investment in productivity-enhancing and welfare aligned technologies, feed systems, animal health, traceability, and climate-resilient production systems. It is unlikely that India will sustain a pathway on which future protein growth is driven primarily by expanding or intensifying animal populations, increasing feed dependency, or deepening pressure on already constrained natural resources. In dairy, future growth will depend on productivity improvements, climate- and water-resilient feed systems, stronger animal health and welfare practices, and substantial methane reduction. In poultry and aquaculture, growth is likely to depend on better husbandry and animal welfare, reduced antibiotic dependency, stronger biosecurity systems, improved feed efficiency, traceability, and reduced operational losses. The challenge throughout India's protein systems is to improve output sustainably per unit of land, water, feed, and emissions, also in an ethical manner.

2. Protein diversification must move from niche conversation to mainstream strategy. Policymakers can support this through research, innovation, and enabling regulation, while companies, investors, and food-service providers can help expand markets, infrastructure, and consumer access. The modelling suggests that production-side mitigation alone is unlikely to align future protein demand growth with climate-safe pathways. Diversification should therefore be viewed both as a climate mitigation lever and a resilience strategy that can reduce pressure on feed systems, water resources, and emissions-intensive supply chains. For India, the opportunity is to strengthen lower-emissions protein pathways that already have a strong consumption base, while investing in processing capacity, ingredient infrastructure, public procurement, and emerging protein innovation.

3. Transition costs cannot simply be pushed upstream. Large buyers, financial institutions, and public programmes will need to play a greater role in financing and de-risking transition costs for producers. This remains one of the most significant transition risks in a food system where smallholders, fragmented producers, contract growers, and MSMEs dominate output but sustainability expectations are increasingly transmitted through large processors, exporters, retailers, and formal buyers. Without stronger smallholder engagement, financing mechanisms, procurement reform, corporate support, technical assistance, and public support systems, transition costs are likely to be pushed toward the producers least equipped to absorb them. That would create both political resistance and weaker long-term outcomes. At the same time, the expansion of low-cost traditional pulses or value-added plant-protein crops is a key strategy for climate resilience, and accessible and affordable protein security.

Capital allocation can strongly shape the pace of transition. Companies, investors, lenders, development finance institutions, and public agencies need to play a decisive role in determining which protein systems scale over the next two decades. This includes capital allocation for the highest-impact mitigation levers, financing for climate-resilient crops and feed innovation, cold-chain infrastructure, traceability systems, pulse processing, alternative protein manufacturing (including R&D for fermented and cultivated proteins), smallholder and MSME transition support, and aligned animal health and welfare systems.

This is particularly relevant for alternative proteins, where equipment costs, import-dependent precision components, certification gaps, and limited shared infrastructure are barriers to scaling domestic manufacturing. The binding constraint may not be demand but whether capital reinforces existing vulnerabilities or flows toward a diverse set of more resilient and diversified protein systems.

India’s protein transition should be viewed as a strategic question of food security, resilience, and long-term competitiveness. The choices made over the coming decades will shape both emissions outcomes and the future resilience of supply chains, rural livelihoods, natural resources, and protein security. The transition window remains narrow and urgent, but the opportunity – to shape a more resilient and diversified pathway before high-emissions dependencies become further locked in – is enormous.

Annex

Data Inputs, Modelling Framework, and Validation Approach

This report draws on modelling of India's protein demand and emissions pathways through 2070, supplemented by secondary research and targeted expert consultations across dairy systems, livestock economics, poultry systems, and emerging proteins.

The modelling draws on FAO GLEAM emissions data, Government of India livestock statistics, fisheries datasets, and targeted expert consultations. Additional datasets were used selectively to validate sector-specific assumptions related to production systems, consumption trends, and resource constraints. The expert consultations were used to sense-check assumptions, strengthen sector-specific context and interpretation. Unless explicitly cited, qualitative insights in this report should not be attributed to any individual.

Key Sources for Modelling data:

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Sunayana Sibal	Varaha Impact Foundation	Dairy systems, field implementation
Aiyanna Belliappa	GFI India	Smart proteins

Endnotes

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