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59th Annual General Meeting (AGM) & 67th National Symposium 2026 11th & 12th September 2026

Theme : Animal Agriculture: The Backbone of Sustainable Development

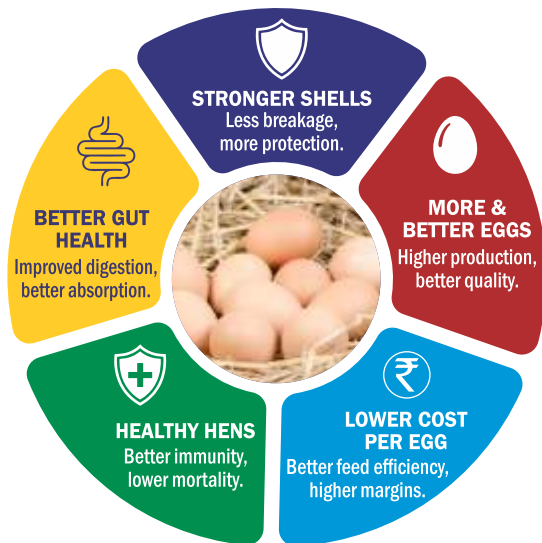
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³ Influence of the Origin of the Beans on the Chemical Composition and Nutritive Value of Commercial Soybean Meals, Universidad Politécnica de Madrid (García-Rebollar et al.), Animal Feed Science and Technology, 2026.

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CONTENTS

MESSAGE

Shri. Piyush Goyal - Minister of Commerce & Industry Government of India, New Delhi	15
Prof. S. P. Singh Baghel - Minister of State, Fisheries Animal Husbandry & Dairying and Ministry of Panchayati Raj, Government of India, New Delhi	17
Shri. Bhagirath Choudhary - Minister of State, For Agriculture & Farmers Welfare Government of India, New Delhi	19
Shri. Naresh Pal Gangwar - Secretary, Fisheries Animal Husbandry & Dairying, Department of Animal Husbandry & Dairying Government of India, New Delhi	21
Smt. Constance Cullman - Chair, International Feed Industry Federation	23
Mr. NICOLÒ CINOTTI - Secretary General, International Poultry Council	25

WELCOME ADDRESS OF CONVENOR 28

CHAIRMAN'S ADDRESS 30

PROGRAMME SCHEDULE 32

CLFMA AWARDEES 49

TECHNICAL SESSION - SPEAKER / PANELIST BIO DATA

Ms. Varsha Joshi	54
Mr. Tarun Shridhar	56
Mr. Sunil Kataria	57
Ms. Manisha Gupta	58
Mr. Balram Singh Yadav	59
Mr. Suresh Chitturi	60
Mr. Daljeet Singh Gill	62
Mr. Sumit Sureka	63
Dr. Saurabh Shekhar	64
Mr. Kavin Roepke	65
Mr. Mrituenjay Kumar	66
Mr. Divya Kumar Gulati	67
Mr. Ranpal Dhanda	68
Mr. Uday Singh Bayas	69

CONTENTS

TECHNICAL SESSION - SPEAKER / PANELIST BIO DATA

Mr. Madan Mohan Maity	71
Mr. Saji Chacko	72
Mr. R. Ramkutty	73
Mr. Bhaskar Karampudi	74
Mr. Shrivardhan Waman Bhawe	75
Dr. Mahesh Subhash Patlapati	76
Dr. Gagan Garg	78
Prof. (Dr.) Pankaj Kumar Shukla	79
Mr. Naveen Pasupathy	81
Dr. Ajay Deshpande	83
Mr. Valsan Parameswaran	85
Mr. Abhay Shah	87

ARTICLES OF INTEREST

Animal Agriculture: The Backbone of Sustainable Development	88
Transforming Livestock Farming by Using Digital Technologies	95
Sustainable Livestock Farming: Empowering Rural Livelihoods And Food Security	98
Artificial Intelligence: Transforming the Future of Animal Feeding	106
Balanced Feeding: A Sustainable Pathway to Improving Dairy Animal Productivity in Developing Countries	109
Microbial Fermentation of Fish Feed: A Sustainable Innovation At The Heart Of Animal Agriculture	113
Short Chain Fatty Acids (SCFAS): A Promising Functional Feed Additives to Improve Fish Health And Growth Performance	116
Strawlage: Fermenting A Circular Economic Pathway For Sustainable Livestock Feeding	119

OUR SPONSORS 123

OUR ADVERTISERS 132



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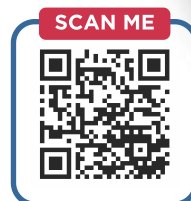
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MESSAGE

I am pleased to learn that The Compound Feed Manufacturers Association (CLFMA) of India is organising its 67th National Symposium on 11th and 12th September 2026 in Mumbai with the theme of 'Animal Agriculture : The Backbone of Sustainable Development'. A souvenir is also being published on this occasion.

Animal agriculture plays a vital role in India's rural economy, food security and livelihoods. The Government of India, under the dynamic leadership of our Hon'ble Prime, Shri Narendra Modi ji, has taken various steps of strengthen the livestock sector, including greater productivity, technology, adoption, sustainable practices, animal welfare and value addition. A modern and resilient animal agriculture ecosystem can create new opportunities for farmers, entrepreneurs and industry.

I commend CLFMA of India of its continued efforts towards strengthening the livestock and animal protein value chain and for providing a platform for meaningful dialogue and knowledge sharing. The Symposium will provide an important forum for stakeholders to exchange experiences, discuss emerging challenges and explore innovative approaches to enhancing productivity, sustainability and value creation across the sector. I am confident that the discussions will contribute valuable insights and actionable ideas for the future of animal agriculture in India.

I extend my best wishes to CLFMA of India for the success of the Symposium and for its continued contribution towards the sustainable development of India's livestock sector.

(Piyush Goyal)

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Prof. S. P. Singh Baghel
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MESSAGE

It gives me immense pleasure to convey my warm greetings and best wishes to the CLFMA OF INDIA on the occasion of its 67th National Symposium, 2026, being organized on 11th and 12th September, 2026 in Mumbai, on the theme "Animal Agriculture: The Backbone of Sustainable Development."

Since its establishment in 1967, CLFMA OF INDIA, an association of Livestock Sector has made significant contributions towards the development of India's livestock sector by bringing together industry leaders, policymakers, researchers, farmers, and other stakeholders on a common platform. Over the years, the organization has played an important role in promoting scientific animal nutrition, technological advancement, productivity enhancement, and sustainable practices across the livestock value chain.

Animal husbandry, dairying, poultry, and fisheries are integral to India's rural economy and play a vital role in enhancing farmers' incomes, generating employment, ensuring nutritional security, and strengthening the overall socio-economic development of the country. With the growing demand for quality animal protein and the need for sustainable agricultural practices, the livestock sector is poised to make an even greater contribution to India's journey towards a resilient and self-reliant economy.

The theme of this year's Symposium is both timely and significant. Sustainable animal agriculture requires a coordinated approach encompassing scientific research, innovation, animal health and welfare, efficient feed and nutrition management, climate resilience, environmental sustainability, and the adoption of modern technologies. Platforms such as the CLFMA National Symposium provide an excellent opportunity for meaningful deliberations and collaboration among all stakeholders to address emerging challenges and identify new avenues for growth.

I am also pleased to learn about CLFMA's Students Program, which seeks to encourage young minds to undertake research and projects addressing real-world challenges in poultry, dairy, and aquaculture. Such initiatives are important for strengthening the linkages between academia and industry and for nurturing the next generation of professionals, researchers, and entrepreneurs in the livestock sector.

I am confident that the deliberations at the 67th National Symposium 2026 will generate valuable insights and actionable ideas that will contribute to the sustainable and inclusive growth of India's animal agriculture sector.

I extend my sincere appreciation to the office bearers and members of CLFMA, as well as the organizers, experts, international delegates, and all participants of CLFMA of India, for their continued efforts, dedication, and commitment to the advancement of the livestock sector. My best wishes for the grand success of the 67th National Symposium 2026 and for the continued growth and progress of CLFMA OF INDIA.

(Prof. S. P. Singh Baghel)

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MESSAGE

I am pleased to learn that CLFMA of India is organizing its **67th National Symposium, themed "Animal Agriculture: The Backbone of Sustainable Development,"** scheduled to be held on 11th and 12th September 2026 at The Leela Mumbai. It is also commendable that a Souvenir is being published to commemorate this significant milestone.

As a premier organization representing the complete animal protein value chain since 1967, CLFMA of India has played a pivotal role in driving dialogue, innovation, and advocacy across the livestock sector. This initiative perfectly aligns with the vision of Hon'ble PM Modi ji's for a Viksit and Aatmanirbhar Bharat, underscoring the critical contribution of animal agriculture, poultry, dairy, and aquaculture to India's rural economy and food security.

Platforms like the National Symposium provide an invaluable forum for leading experts, industry leaders, and policymakers to deliberate on emerging trends and actionable strategies. Furthermore, initiatives like the Students Program are highly commendable, as they bridge the gap between academia and industry, nurturing young talent to solve real-world challenges and fostering future-ready professionals for the sector.

I extend my best wishes to the organizers, participants, and delegates for the grand success of the 67th National Symposium and the publication of the Souvenir.

(Bhagirath Choudhary)

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MESSAGE

The Indian livestock sector has demonstrated remarkable growth over the past decade, with Gross Value Added (GVA) rising significantly between 2014-15 and 2023-24, outpacing the crop sector. Its resilience has made it a vital pillar of the national economy, consistently contributing 5.5% to the national GVA and serving as a buffer during economic fluctuations. Exports have also expanded steadily, reaching `66,249 crore in 2024-25, driven by the strong performance of the meat industry, particularly bovine meat and edible offal.

Against this backdrop, the upcoming **67th National Symposium** on 11-12 September 2026, themed "Animal Agriculture: The Backbone of Sustainable Development" and organized by CLFMA of India, deserves special mention.

Despite notable progress, the sector continues to face challenges such as feed and fodder shortages, disease outbreaks, shrinking grazing lands and inadequate veterinary infrastructure. Addressing these requires a blend of technological, institutional and policy measures – including stronger disease surveillance, affordable quality feed and fodder, genetic improvement programs, improved infrastructure, public-private partnerships and sustainable practices.

In line with the vision of self-reliance and sustainable growth, the Government of India has launched various development programmes. The **Rashtriya Gokul Mission (RGM)**, continues to strengthen indigenous bovine breeds, boost milk production and make dairying more rewarding for rural farmers. Besides, various flagship initiatives such as the **National Livestock Mission (NLM)**, are being implemented which focus on employment generation, entrepreneurship development and productivity enhancement. As a result, India is the largest milk producer in the world today.

CLFMA has consistently played a proactive role in highlighting feed-related issues to the Government of India. I sincerely appreciate its dedicated efforts toward the holistic advancement of the livestock and aquaculture sector. The CLFMA Student's Programme could prove to be a wonderful initiative to bridge the gap between academia and the livestock industry. I am confident that the 67th National Symposium will generate valuable suggestions and proposals for the sector's continued development.

On this occasion, I extend my best wishes for the grand success of CLFMA's National Symposium.


(Naresh Pal Gangwar)

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MESSAGE

It gives me immense pleasure to learn that the Compound Livestock Feed Manufacturers Association (CLFMA) of India is organizing its 67th National Symposium themed "Animal Agriculture: The Spine of Sustainable Development".

The livestock sector continues to occupy a pivotal position in India's agricultural economy and rural livelihood framework. The export performance of the livestock sector has been equally encouraging, with exports reaching approximately `66,249 crore during 2024-25, reflecting the increasing competitiveness of Indian livestock products in international markets.

The theme of this symposium is both timely and significant. As animal rearing becomes increasingly important for food security, farmer welfare and sustainable development, addressing challenges related to feed and fodder availability, animal health, climate resilience and infrastructure will require strong collaboration between government, industry and academia.

To accelerate the growth of the livestock sector, the Government of India has launched several flagship programmes, which aim at improving productivity, strengthening animal health care services, expanding infrastructure facilities, fostering entrepreneurship and, promoting private investment in Animal Husbandry Sector.

I appreciate CLFMA's valuable contribution to the livestock sector and am confident that the symposium will promote meaningful dialogue and support sustainable sectoral growth. I congratulate CLFMA on organizing this important event and extend my best wishes for the success of the 67th National Symposium.

With best wishes,

(Dr. Muthukumarasamy B.)



**International Feed Industry
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15 August 2026

Constance Cullman
Chair
International Feed Industry Federation

MESSAGE

REF: Message from the Chair of the International Feed Industry Federation

Dear CLFMA Members, Colleagues and Symposium Participants,

On behalf of the International Feed Industry Federation (IFIF), it is my pleasure to extend warm greetings and best wishes to CLFMA of India on the occasion of its 67th National Symposium.

This year's theme, "Animal Agriculture: The Backbone of Sustainable Development," is both timely and highly relevant. Animal agriculture plays an essential role in supporting food and nutrition security, rural livelihoods and economic development. This is particularly evident in India, where the livestock sector supports millions of farmers and communities and contributes significantly to the country's agricultural economy.

The feed industry is an integral part of this contribution. Through innovation, responsible resource use and strong collaboration across the value chain, our sector can help improve productivity, protect animal health and welfare, and support the production of safe, nutritious, sustainable and affordable food.

IFIF greatly values its longstanding relationship with CLFMA of India and appreciates its important work on behalf of the Indian livestock and feed sectors. We also commend CLFMA for continuing its Students Program. Connecting talented young people with industry and encouraging them to address real-world challenges is an important investment in the future of animal agriculture.

IFIF represents more than 80% of global compound feed production. Working closely with our members and partners across the agricultural value chain, we address key priorities including feed and food safety, sustainability and good production practices. Through cooperation and the exchange of knowledge and expertise, we can continue strengthening our industry and its contribution to sustainable development.

On behalf of the IFIF Board of Directors, I wish all participants productive deliberations, fruitful discussions and a highly successful 67th National Symposium.

Sincerely,

Constance Cullman

Constance Cullman
Chair
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NICOLÒ CINOTTI
Secretary General
International Poultry Council

MESSAGE

On behalf of the International Poultry Council (IPC), it is a great pleasure to extend our warmest greetings to all participants of the 67th National Symposium of the Compound Livestock Feed Manufacturers Association (CLFMA) of India.

This year's theme, **"Animal Agriculture: The Backbone of Sustainable Development,"** comes at an important moment for our sector. As the global population grows and food systems face increasing pressures related to resources, climate, affordability and resilience, animal agriculture has a vital role to play in delivering safe, nutritious and accessible food while contributing to sustainable economic development.

For the poultry sector in particular, this responsibility also represents an opportunity. Through continued innovation, improvements in resource efficiency, responsible production practices and investment in animal health and welfare, our industry can contribute to building food systems that are not only productive, but also resilient and sustainable over the long term.

Achieving this ambition requires collaboration across the entire value chain. Producers, feed manufacturers, researchers, policymakers, industry leaders and other stakeholders each have an essential role to play. Platforms such as the CLFMA National Symposium are therefore invaluable in bringing together different perspectives, encouraging the exchange of knowledge and turning dialogue into practical solutions.

We also commend CLFMA for its continued commitment to fostering innovation and developing the next generation of professionals through initiatives such as the Students Program. Preparing young talent to address the challenges facing animal agriculture will be essential to ensuring that our sector remains dynamic, science-based and future-ready.

The International Poultry Council is proud to work alongside organizations such as CLFMA in advancing a poultry sector that contributes positively to global food security and sustainable development. We look forward to strengthening our collaboration and to sharing experiences and solutions that can benefit animal agriculture in India and around the world.

We wish CLFMA and all participants a highly successful 67th National Symposium, and we are confident that the discussions and partnerships emerging from this gathering will help shape a more resilient, innovative and sustainable future for animal agriculture.

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Convenor Address



It is my great pleasure and privilege to extend a warm welcome to our distinguished Chief Guest, Guests of Honour, eminent speakers, panelists, delegates, policymakers, scientists, academicians, technocrats, industry leaders, entrepreneurs, representatives of the Government of India, international participants, and all esteemed guests to the 59th Annual General Meeting and the 67th National Symposium of CLFMA OF INDIA, being held on 11–12 September 2026 at The Leela Mumbai, Sahar, Near International Airport, Andheri East, Mumbai.

Your gracious presence reflects the growing importance of this premier national platform dedicated to advancing India's animal agriculture sector. It is heartening to witness such a distinguished gathering of policymakers, researchers, scientists, industry leaders, entrepreneurs, and stakeholders, united by a shared vision of building a sustainable, resilient, and globally competitive livestock sector.

The theme of this year's National Symposium, "Animal Agriculture: The Backbone of Sustainable Development," is both timely and significant. Animal agriculture remains a vital pillar of India's rural economy, contributing to nutritional security, employment generation, farmers' income, women's empowerment, and overall economic growth. As India moves towards the vision of becoming a developed nation by 2047, the livestock sector will play an increasingly important role in ensuring sustainable and inclusive development. While the sector faces challenges such as climate change, disease outbreaks, feed and fodder shortages, rising production costs, and changing consumer expectations, these challenges also create opportunities for innovation. Emerging technologies, including precision livestock farming, artificial intelligence, biotechnology, digital traceability, sustainable feed solutions, circular bio-economy, and climate-smart production systems, are transforming the future of animal agriculture.

The 67th National Symposium 2026 has been designed as a platform for meaningful dialogue, knowledge exchange, and collaboration among policymakers, researchers, industry experts, entrepreneurs, and other stakeholders. Over the next two days, participants will engage in insightful technical sessions and panel discussions covering emerging technologies, policy and regulatory developments, food and nutrition security, industry collaboration, market opportunities, and strategies for the sustainable growth of India's livestock sector. We sincerely appreciate the Government of India's continued commitment to strengthening the livestock sector through landmark initiatives such as the Rashtriya Gokul Mission, National Livestock Mission, Pradhan Mantri Matsya Sampada Yojana, Animal Husbandry Infrastructure Development Fund, and several programmes promoting animal health, breed improvement, infrastructure development, and value addition. These initiatives continue to provide a strong foundation for the sustainable growth of the sector.

As the apex association representing the animal feed and allied livestock industries, CLFMA OF INDIA remains committed to promoting scientific research, technological innovation, policy advocacy, industry collaboration, and sustainable development. Through this Symposium, we aim to facilitate meaningful discussions, encourage stronger partnerships, and identify practical solutions that will strengthen India's animal agriculture ecosystem.

On behalf of the CLFMA Office Bearers, Managing Committee, and Organising Committee, I express my sincere gratitude to our Chief Guest, Guests of Honour, Hon'ble Ministers, Senior Government Officials, Consuls General, Their Excellencies the Ambassadors, distinguished moderators and speakers, sponsors, industry partners, exhibitors, members of the media, and every delegate whose valuable support and participation have made this event possible.

I am confident that the deliberations during the Symposium will generate valuable insights, inspire innovation, foster meaningful collaborations, and contribute to shaping policies and practices that will drive the sustainable growth of India's livestock sector

I wish you all a productive, enriching, and memorable 67th National Symposium 2026 and a pleasant stay at The Leela in Mumbai.

Let us work together to strengthen Animal Agriculture as the true backbone of sustainable development and build a prosperous future for India's livestock sector.

Thank you,
Warm Regards,



Suresh Deora
Convenor of 67th National Symposium, 2026
CLFMA OF INDIA

Chairman's Address



It is with great pleasure that I welcome you to the **59th Annual General Meeting and 67th National Symposium** of CLFMA OF INDIA, being held on **11th and 12th September 2026 at The Leela, Mumbai.**

I extend my warm greetings to our Chief Guest, Guests of Honour, distinguished dignitaries, government officials, industry leaders, researchers, academicians, valued partners, sponsors and delegates who have travelled from across the country and overseas to be part of this important gathering. Your presence reflects the collective commitment to strengthening India's animal agriculture sector and shaping its future.

The theme of this year's symposium, "**Animal Agriculture – The Backbone of Sustainable Development,**" reflects the growing significance of the livestock sector in India's development journey. Agriculture and allied activities currently contribute about 18% of India's Gross Value Added (GVA), with the sector's GVA more than doubling from ₹20.94 lakh crore in 2014–15 to ₹48.78 lakh crore in 2023–24. Within this, the livestock sector has emerged as a key growth driver, contributing 30.87% of the Agriculture & Allied Sector GVA, while its own GVA has nearly tripled over the past decade from ₹5.10 lakh crore to ₹15.06 lakh crore. These figures underscore the sector's expanding economic contribution alongside its role in supporting rural livelihoods, strengthening nutritional security and creating opportunities across dairy, poultry, aquaculture and allied industries. As India advances towards a more resilient and inclusive economy, animal agriculture will remain central to driving sustainable growth through higher productivity, scientific innovation and value creation.

With this objective, CLFMA OF INDIA continues to encourage greater participation from students and young professionals, recognising them as future researchers, entrepreneurs and industry leaders. This year as well 5 students from each sector (Poultry, Dairy, Aqua) have been selected based on the submission made by them. By providing opportunities to engage with experts and present innovative ideas, we hope to inspire the next generation to contribute meaningfully to the continued advancement of animal agriculture.

This year's symposium has been designed around these priorities. Over the next two days, we will hear from eminent policymakers, government representatives, industry veterans and subject matter experts who will share their perspectives on some of the most significant developments shaping animal agriculture today. The discussions will examine emerging opportunities, evolving policy priorities and the practical pathways that can support long-term sectoral growth.

One of the key highlights of this year's programme is the policy roundtable, bringing together senior representatives from the Government of India alongside industry leaders to deliberate on

strengthening partnerships between government and the sector. Constructive dialogue has always been essential for creating an enabling ecosystem, and forums such as these provide an opportunity to address challenges, exchange perspectives and collectively identify solutions that can benefit producers, businesses and consumers alike.

The symposium will also explore how emerging technologies are influencing the future of animal agriculture. The increasing application of artificial intelligence and digital technologies presents significant opportunities to improve productivity, strengthen decision-making, enhance animal health management and optimise production systems. Equally important is ensuring that innovation remains practical, accessible and capable of delivering measurable value across the livestock ecosystem.

For nearly six decades, CLFMA OF INDIA has remained committed to bringing together stakeholders across the value chain to foster dialogue, encourage scientific advancement and support the growth of India's livestock and allied sectors. Our annual symposium continues to serve as an important platform where ideas are exchanged, partnerships are strengthened and meaningful conversations translate into actionable outcomes for the industry.

As we gather in Mumbai, I am confident that the conversations over the next two days will generate fresh perspectives, encourage stronger partnerships and inspire practical solutions that advance the interests of India's animal agriculture sector. The collective wisdom assembled here represents a valuable opportunity to shape a future that is innovative, sustainable and globally competitive.

I extend my sincere appreciation to our sponsors, Office Bearers, Managing Committee Members, organising teams and every member of the CLFMA family whose dedication has made this event possible. My heartfelt thanks also go to every delegate for your continued trust, participation and commitment to the advancement of our industry.

I wish you an engaging symposium filled with insightful discussions, meaningful collaborations and ideas that contribute to the continued growth of animal agriculture and its enduring contribution to sustainable development.

With Regards,



Divya Kumar Gulati
Chairman
CLFMA OF INDIA

PROGRAMME

59th AGM & 67th National Symposium 2026

Date: 11th and 12th September, 2026 at
The Leela Mumbai, Sahar, Near International Airport, Andheri East, Mumbai

Theme: "Animal Agriculture-The Backbone of Sustainable Development"

Day-1: Friday, September 11th, 2026

Time	Session
10:00 hrs	Registration of Delegates
12:00 hrs - 13:30 hrs	Lunch
13:30 hrs - 14:30 hrs	59 th Annual General Meeting
Time	Inaugural Session
15:40 hrs.	Inviting Dignitaries to the Dais inauguration & Lighting of Lamp
15:50 hrs	Welcome Address by Convenor Mr. Suresh Deora, Immediate Past Chairman, CLFMA OF INDIA
16:00 hrs	Address by Chief Guest Shri. Piyush Goyal, Hon'ble Minister of Commerce and Industry, Department of Commerce, GOI
16:30 hrs	Chairman Address by Mr. Divya Kumar Gulati, CLFMA OF INDIA
16:40 hrs	Keynote Address by Shri. Tarun Shridhar, IAS, (Retd.)
16:50 hrs	CLFMA Awards & Students Awards Ceremony
17:00 hrs	Address by Special Guest , Dr. Muthukumarasamy B., Joint Secretary (NLM), Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India
17:10 hrs	Address by Special Guest , Ms. Varsha Joshi, Additional Secretary (CDD), Department of Animal Husbandry and Dairying, GOI
17:20 hrs	Address by Special Guest , Mr. Naresh Pal Gangwar, Secretary AHD, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India
17:35 hrs	Address by Guest of Honour , Prof. S. P. Singh Baghel, Hon'ble Minister of State of Fisheries, Animal Husbandry & Dairying and Ministry of Panchayati Raj, Government of India
18:05 hrs	Launching Souvenir 2026 & Survey Report 2026-2030
18:10 hrs	Vote of Thanks by Mr. Nissar F. Mohammed, Honorary Secretary, CLFMA OF INDIA
19:00 hrs	Networking Dinner & Live Performance Felicitation of Sponsors, Media, Guests, and Invitees

Day-2: Saturday, 12th September, 2026

09:00 hrs	Registration
09:15 hrs	Welcome Address by Mr. Divya Kumar Gulati, Chairman, CLFMA OF INDIA
09:30 hrs	Introduction of Symposium – (Technical Committee Member)
10:00 hrs	Mr. Sunil Kataria, CEO & MD, Godrej Agrovet Ltd- Theme based Presentation
11:00 hrs	Interactive Policy – Roundtable / Government and sector partnership for animal agriculture Moderator: Ms. Manisha Gupta, Editor – Commodities & Currencies, CNBC ❖ Ms. Varsha Joshi, Additional Secretary (CDD), Department of Animal Husbandry and Dairying, GOI ❖ Dr. Muthukumarasamy B., Joint Secretary (NLM/SD), Department of Animal Husbandry & Dairying, GOI ❖ Mr. B. S. Yadav, Ex-Managing Director, Godrej Agrovet Ltd. ❖ Shri. Suresh Rayudu Chitturi, Vice Chairman and MD, Srinivasa Farms ❖ Shri. Daljeet Singh, President, Progressive Dairy Farmers Association (PDFA) ❖ Mr. Sumit Sureka, Dy. Chairman, CLFMA OF INDIA
12:00 - 13:00 hrs	Presentation on Pet Food - Dr. Saurabh Shekhar, Managing Partner – Pet Care, Pet Care Business
13:00 - 14:00 hrs	Lunch Break
14:00 - 14:15 hrs	Kevin Roepke, Executive Director MENASA, U.S. Soybean Export Council
14:15 hrs	Panel Discussions with National Associations - One Nation One Voice Moderator: Mr. Mrityunjay Jha, Commodity Editor and Anchor, Zee Business ❖ Mr. Divya Kumar Gulati, Chairman, CLFMA OF INDIA ❖ Mr. Ranpal Dhanda, President, Poultry Federation of India (PFI) ❖ Mr. Uday Singh Bayas, President, Indian Poultry Equipment Manufacturers Association (IPEMA) ❖ Mr. Madan Mohan Maity, General Secretary, West Bengal Poultry Federation Association (WBPFA) ❖ Mr. Saji Chako, President, Society of Aquaculture Professionals (SAP) ❖ Mr. R. Ramkutty, Broiler Co-ordination Committee (BCC)
15:15 hrs-16:00hrs	Presentation on AI in animal agriculture (Mr. Bhaskar)
16:00 hrs	Panel discussions: Animal Agriculture and Global Food Security Moderator: Mr. S. V. Bhawe, Managing Director, Berg And Schmidt India Pvt. Ltd. ❖ Dr. S. K. Dutta, Joint Commissioner (NLM), Dept of AH&D, GOI ❖ Dr. P. S. Mahesh, Joint Commissioner and Director, CEAH-Bengaluru ❖ Dr. Gagan Garg, Joint Commissioner (RGM), Department of Animal Husbandry and Dairying, GOI ❖ Prof. (Dr.) Pankaj Kumar Shukla, President, Indian Poultry Science Association ❖ Mr. Naveen Pasupathy, President, Karnataka Poultry Farmers & Breeders Association (KPFBA) ❖ Dr. Ajay Deshpande, President, Vets In Poultry (VIP) ❖ Mr. Valsan Parameswaran, Secretary, All India Poultry Products Exporters Association (AIPPEA) - Egg
17:00 hrs	Valedictory Session: Mr. Abhay Shah, Dy. Chairman, CLFMA OF INDIA
17:15 hrs	Vote of Thanks by – Mr. R. Ramkutty, Treasurer, CLFMA OF INDIA
19:00 hrs	Networking Dinner

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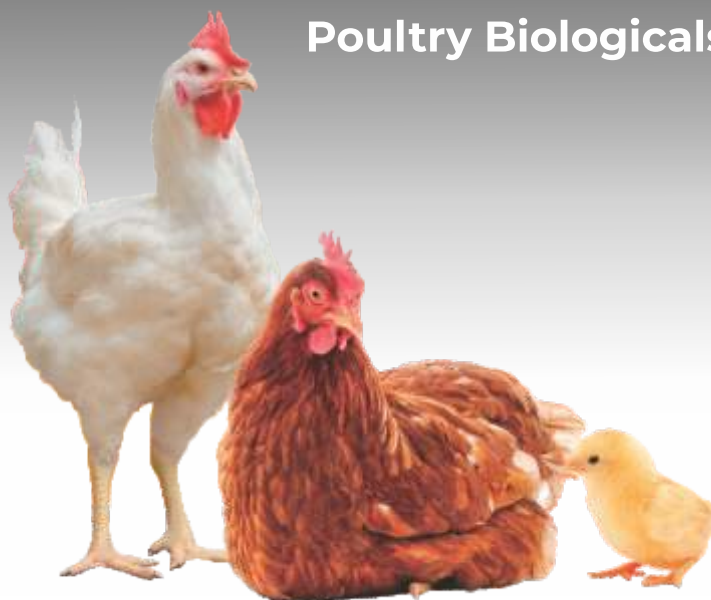
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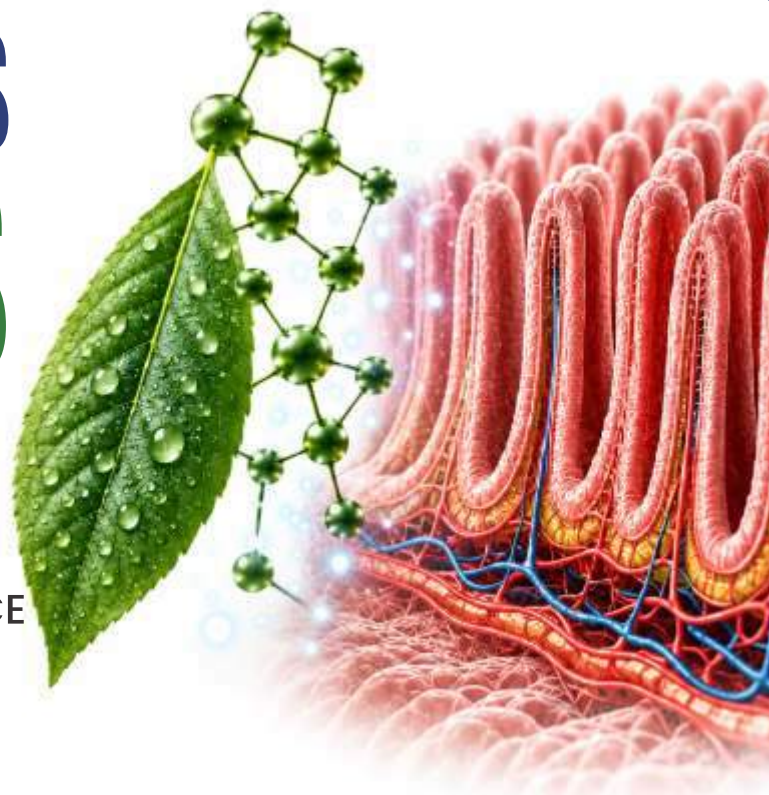
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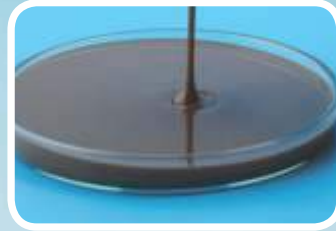
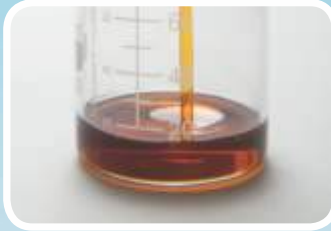
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EARLY LIFE & BACKGROUND

- Born in Ikas village, Haryana, to an agricultural family. Schooling in Ikas and Ramrai; matriculated 1971, graduated from Jind 1976. Arts background, no formal training in industry.
- Trained in electronics at the Patiyala Electronic Shop, Karnal; also worked in motor-binding and wood casing. Left a government job in the field, determined to build his own business rather than take up service.
- First venture — a factory making wooden parts for the electronics industry — failed when Assam timber proved substandard. He used that timber to build his first poultry shed.
- Family opposed the move on grounds of risk; his father did not visit the farm for two years. Sustained early on by his elder brother's savings.

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- Named after the skylark, a migratory bird that keeps to the same path and timing each year — commitment and punctuality as founding ideals.
- Began with parent operations of the Cockerel breed, when meat consumption was limited and breeds undeveloped.
- 2010 — entered Grand Parent Operations, one of only a handful of Indian companies to do so; today runs Hubbard and Bovans GP stock from France.
- Built seven verticals: Grand Parent Operations, Parent Stock Broiler, Parent Stock Layer, Hatchery, Poultry Processing, Feed Production and Poultry Equipment.
- Nationwide network of farms, processing plants, distributors, trade partners and contract farmers; processed chicken supplied under the brand Nutrich.

FEED & NUTRITION

- Brought feed manufacturing fully in-house after finding bought-in feed quality inadequate — on the conviction that quality meat and eggs begin with quality feed.

- Present capacity approximately 3,000 metric tons of feed per day.
- Established the company's own Solex plant at Ujjain, Madhya Pradesh.
- Launched Dhaar, a cattle feed brand, extending the same standard to cattle welfare and putting effective feed within farmers' reach at lower cost.
- Feed manufacturing facility established in Nepal; Layer G.P., Layer Parents, Commercial Layer, hatcheries and feed mills developing in Ghana and Africa — driven by nutritional deficit as much as commercial prospect.

ENGINEERING & INNOVATION

- Designs his own equipment where most Indian poultry companies import: single-stage incubators, fans, biogas plants and feed mill machinery, purpose-built and waste-free.
- Imported twenty-four European machines solely to benchmark his own; his machines proved 2% more energy efficient.
- Known locally as the 'X-ray machine' for his ability to see through any machine's workings and build a better version.
- Credits the company's R&D team as central to its growth and to running a vertically integrated business.

SUSTAINABILITY, BIOSECURITY & FARMER WELFARE

- Negative carbon emissions, zero waste and water recycling across operations.
- Indigenously designed biogas plants; all breeding farms remove litter instantly and process it into biogas, electrical energy and fuel briquettes, cutting dependence on grid power and diesel.
- Biofertilizers generated are supplied to farmers free of charge.
- Treats biosecurity as the first principle of a healthy farm, keeping birds well through their lifetime and reducing antibiotic use to a near-negligible level.
- Counters myths and anti-poultry campaigns through education and awareness rather than confrontation.

AWARDS & RECOGNITION

- 2024 — honoured by Tamil Nadu Veterinary and Animal Sciences University (24 June) for contribution to the poultry industry; the company financially supported construction of the college auditorium.
- 2013 — Appreciation Award, 1st Meat and Poultry Summit (CII and FACE); acknowledged at Poultry Tech Expo 2013.
- 2012 — Chief Guest, national seminar on 'Novel Feed Additives' organised by Ayurvet.
- 2011 — Guest of Honour, International Animal Industry Expo; Appreciation Award, Poultry Federation of India, 23rd AGM.
- Recognised by the Haryana State Government and Haryana State Pollution Control Board for environmental protection and poultry waste solutions on World Environment

Day; acknowledged by Hubbard on its 85th anniversary for contributions to the development of the Hubbard breed in India.

- Appreciation from the Indian Chamber of Food and Agriculture for work in poultry and biogas; completed the Hatchery Management Program with excellence.

LEADERSHIP & PHILOSOPHY

- Holds self-motivation, and the ability to draw it from others, as the decisive factor in an industry with little organised support or government incentive.
- Keeps an eight-to-eight shift at seventy; regards work as both entertainment and his chief source of satisfaction.
- Has kept the company off the IPO dashboard, believing one must own the credit for one's own work rather than carry the burden of forced recognition.
- Encourages employees to try new ideas regardless of profit or loss, while ensuring mistakes are not repeated.
- Shares knowledge freely in a field where tactics are guarded; teaches newcomers rather than discouraging them, and treats competitors as occasions for learning. Considers himself a good corporate citizen first and a leader second.



CLFMA Award



Dr. Linganna Muniyappa
Veteran Veterinary Microbiologist

Dr. Linganna Muniyappa is a Veteran Veterinary Microbiologist, educator, and researcher with more than four decades of service to the field. He has spent his career strengthening livestock health, mentoring young scientists, and supporting farming communities across India and East Africa. Dr. Muniyappa earned his B.V.Sc from UAS Bengaluru (1971), M.V.Sc from G.B. Pant University, Pantnagar (1973), and Ph.D from the Bulgarian Academy of Sciences, Sofia (1986).

Over the course of his career, Dr. Muniyappa has published 72 research papers and presented 35 papers at national and international conferences. His contributions have earned several honors, including the Bulgarian Scholarship Award, the Best Expatriate Teacher Award from Addis Ababa University, the Indian Veterinary Association Award for contributions to microbiology, and the Venkateswara Hatcheries Pvt. Ltd. Award for poultry research. He has also served on expert committees for DBT, Government of India, and the ICAR-QRT Review Committee.

He served for 30 years in the Department of Veterinary Microbiology, rising from Instructor to Professor and Head. During this time, he guided 27 Master's students and carried out research on major livestock challenges such as TB, IBR, Brucellosis, antimicrobial-resistant mastitis biofilms, and key poultry diseases including MD, NDV, Colibacillosis, and IBD. His work was supported by private industry, university grants, state agencies, ICAR, and DBT. From 2005 to 2017, he served as a Professor under the UNDP program at Addis Ababa University, Ethiopia. He helped establish the Master's program in Microbiology at Gondar University, supervised 12 Master's theses, and published 16 scientific papers during his tenure.

Alongside his academic career, Dr. Muniyappa spent 20 years as a Consultant to Mysore Feeds, working directly with dairy and poultry farmers across Karnataka, Andhra Pradesh, and Tamil Nadu. This field experience shaped his practical understanding of disease management and farm-level challenges.

Dr. Muniyappa has traveled widely for academic and professional engagements, visiting scientific institutions and conferences across India, the USA, Europe, Scandinavia, and the Far East.



CLFMA Award



Dr. Shivani Katoch

Distinguished Veterinary Scientist and Academician

Dr. Shivani Katoch is a distinguished veterinary scientist and academician currently serving as **Professor & Head, Department of Animal Nutrition, DGCN College of Veterinary & Animal Sciences, CSK Himachal Pradesh Krishi Vishvavidyalaya (CSKHPKV), Palampur**. He holds a Ph.D. in Animal Nutrition with a University Gold Medal and has over three decades of professional experience spanning research, teaching, extension education, and livestock development.

His major contribution to the livestock sector lies in the development of **nutritional strategies for improving productivity, profitability, and sustainability of livestock and poultry farming**, particularly in the Himalayan region. His research has focused on probiotics, feed additives, Azolla utilization, alternative feed resources, milk quality improvement, poultry nutrition, climate-resilient livestock production, and value-added animal products. He has successfully led and collaborated on numerous projects funded by ICAR, DST, RKVY, DAHD, and other agencies aimed at improving animal production systems and farmer livelihoods by **development and utilization of local feed resources including** apple pomace utilization, feed resource evaluation, mineral nutrition, bypass fat supplementation, and fodder-based feeding technologies, he promoted cost-effective feeding strategies that improve productivity while reducing feed costs, one of the major constraints in dairy farming

Dr. Katoch has played a significant role in **conservation and improvement of indigenous animal genetic resources**, including the registration of the **Gaddi Dog breed** with ICAR and projects on Spiti horse and donkey conservation. He has also contributed extensively to dairy entrepreneurship, livestock biodiversity conservation, and rural women empowerment programs.

With an extensive publication record comprising research papers, manuals, books, extension literature, and keynote presentations, he has effectively translated scientific knowledge into practical solutions for farmers. His contributions have been recognized through numerous national and international awards, including the **Best Extensionist Award (2023-24)** and leadership positions in the **Animal Nutrition Society of India**, where he currently serves as **Secretary (2024-2028)**. Overall, Dr. Katoch's dairy entrepreneurship initiatives have strengthened farmer livelihoods through better nutrition, milk quality improvement, women empowerment, technology dissemination, and adoption of modern dairy management practices





Ms. Varsha Joshi

Additional Secretary, Cattle & Dairy Development,
Ministry of Fisheries, Animal Husbandry & Dairying,
Government of India

Ms. Varsha Joshi is an IAS officer of 1995 batch, AGMUT cadre and is presently serving as Additional Secretary, Cattle & Dairy Development, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India from July 2020

EXPERIENCE

Additional Secretary, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India – from December, 2021

Joint Secretary, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India- from July, 2020

Additional charge as Chairman, National Dairy Development Board- from December 2020 - 31st May, 2021

Commissioner, North Delhi Municipal Corporation- December 2018 - July 2020

Secretary Power, Secretary Tourism, Commissioner Transport, Government of NCT Delhi- November 2016 - December 2018

Joint Secretary, Ministry of New and Renewable Energy, Government of India- October 2014 - November 2016

Director Administration & NPR, Office of Registrar General & Census Commissioner, India- September 2012 - September 2014

Director Census Operations, Delhi- November 2009 - September 2014

Consultant, United Nations Population Fund (UNFPA)- February 2014 - March 2014

Consultant, United Nations Population Fund (UNFPA)- October 2013 - October 2013

Additional Commissioner Transport, Government of NCT of Delhi- 2009 - 2009

Deputy Commissioner South West District, Government of NCT of Delhi- 2007 – 2009

Additional CEO & Director Finance, Delhi Jal Board- 2007 – 2007

Secretary to the State Government, Government of Arunachal Pradesh, 2004 – 2007

Deputy Commissioner, Lohit District, Arunachal Pradesh- 2004 - 2004

Chairperson, Committee against Sexual Harassment, Government of Chandigarh UT, 2001 – 2003

Director Public Instruction, 2000 – 2002

CEO, Chandigarh Housing Board, 1999 – 2003

Managing Director, Chandigarh Industrial and Tourism Corporation- 2000 – 2002

Sub Divisional Magistrate, Government of NCT of Delhi- 1997 – 1999

EDUCATION

Delhi University Master's degree, Physics (1991 1993)

Hindu College, Bachelor's degree, Physics (1988-1991)

HONORS-AWARDS

UMI Commendable Initiative Award- Best NMT Project- 2019 by Urban Mobility India Conference 2019, Ministry of Housing and Urban Affairs, Government of India

President's Silver Medal for Census of India 2011 in 2013





Tarun Shridhar

Former Officer of the Indian Administrative Service (IAS)

Tarun Shridhar is a former officer of the Indian Administrative Service (IAS) who retired in the year 2019 after putting in 35 years in the government, both in the state and the centre.

Through this period, he served in various capacities in diverse sectors such as land administration, industries, transport, tourism, environment, energy etc. However, it was his stint in the Animal Husbandry and Fisheries sectors that ignited a passion in him to contribute substantially through policy and strategy to propel growth; and post retirement through knowledge, insight and advocacy. Curiously, he was assigned the responsibility of these sectors on different occasions in the state as a punitive posting since in the scheme of governance these were considered low priority.

However, he turned it into an opportunity to make lasting contributions for which, post his retirement, he was conferred an honorary doctorate by one of the country's most prestigious universities viz., Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) Ludhiana. In addition he has been accorded recognition by several organisations through the following awards: a) Distinguished Alumni Award by Hindu College, Delhi; b) Policy Leadership Award for the Dairy Sector by the Agriculture Today Group; c) Honorary Fellowship of the National Academy of Veterinary Sciences; d) Animal Health Policy Leadership Award; e) Lifetime Achievement Award by CLFMA (Association of Indian Livestock Industries); f) Lifetime Achievement Award by the Agriculture Today Group

Tarun Shridhar advises, purely in honorary capacity, the various categories of stakeholders of the Animal Agriculture sector on a regular basis. He is invited to deliver keynote/thematic addresses in major seminars/symposiums/conferences of the sector.

He writes regularly for mainstream publications as also technical journals, both in English and Hindi, and has so far authored more than 250 articles. He has also served on the panels of FAO as an expert on Fisheries and Aquaculture.





Sunil Kataria

Chief Executive Officer & Managing Director

Sunil Kataria is Managing Director & CEO of Godrej Agrovet. He is driving the evolution of the business into a future-ready organisation, anchored in its purpose of crafting abundance through innovation that empowers farmers and nourishes our nation.

Sunil brings over 30 years of leadership experience across consumer-packaged goods, telecom, and retail, with deep expertise in sales, marketing, business strategy, and organisational leadership. He has a strong track record of transforming businesses into future-ready organisations and delivering sustained financial and operational performance.

Prior to joining Godrej Agrovet, Sunil was Managing Director at Raymond Lifestyle Limited, where he managed a diverse portfolio and unlocked significant value through an independent listing. Earlier, he served as CEO of the India & SAARC business at Godrej Consumer Products, where he drove growth in market share, operational performance, and shareholder value.

He currently serves as Chairman of the Indian Society of Advertisers (ISA) and is on the board of the Broadcast Audience Research Council (India) (BARC) and has previously served on the board of the Advertising Standards Council of India (ASCI).

Sunil holds a degree in Economics from Delhi University and an MBA in Marketing from IMT Ghaziabad.

He is a strong believer in possibility thinking, combining strategic vision with operational excellence.





Manisha Gupta

Commodities Editor | Senior Television Anchor | Renowned Market Expert

Manisha Gupta is one of India's most distinguished and respected voices in commodities journalism and business broadcasting. With an illustrious career spanning over two decades, she has established herself as a highly regarded authority on Indian and global commodity markets, bringing exceptional insight and depth to the analysis of developments across energy, metals, agriculture and other critical commodity sectors.

As a senior television journalist and commodities expert associated with CNBC-TV18, Manisha has played a significant role in shaping and strengthening commodities coverage in Indian business media. Her incisive market analysis, authoritative presentations and engaging interactions with leading policymakers, economists, industry leaders and market participants have earned her widespread recognition and credibility.

Known for her ability to interpret complex market movements and global economic developments with clarity and precision, she has consistently provided audiences with valuable perspectives on issues influencing commodity prices, trade and the broader economic landscape.

Manisha's professional journey also encompasses extensive experience in commodities research and market analysis, providing her with a unique combination of analytical expertise and journalistic excellence. She holds a Master's degree in Business Administration and has also pursued advanced studies in international trade and import-export regulations.

An accomplished television anchor and respected market commentator, Manisha Gupta continues to be an influential and trusted voice in India's business and commodities media, contributing significantly to informed dialogue and understanding of the rapidly evolving global commodities landscape.





Mr. Balram Singh Yadav

Independent Director with DAM Capital Advisors
and as Chairman of the Agriculture Skill Council of India.

Balram has spent over three decades at Godrej Agrovet Ltd., serving as Managing Director since 2007, where he led a successful turnaround and scaled the company into a market leader. Under his leadership, the company delivered a 17% CAGR in topline and 22% CAGR in valuation, driven by greenfield investments, strategic acquisitions, and sustained R&D focus—culminating in a landmark public listing in 2017 that was oversubscribed 96 times.

Beyond executive leadership, Balram brings extensive governance experience as a Board Director across multiple companies, including Astec Life Sciences, Creamline Dairy, and ACI Godrej Agrovet. He currently serves as an Independent Director with DAM Capital Advisors and as Chairman of the Agriculture Skill Council of India.

He has advised Central and State Government bodies on policy formulation and has served on committees under the Ministry of Agriculture, CII, and FICCI. Balram brings a strong track record of ethical governance, stakeholder management, and building consensus among diverse groups—skills directly relevant to effective society management.

Balram holds a BSc (Hons.) in Agricultural Sciences and an MBA from IIM Ahmedabad.





Mr. Suresh Chitturi
Chairman and Managing Director
Srinivasa Farms

Suresh Chitturi is Chairman & Managing Director of Srinivasa Farms, which spans chicken breeding, feed, and soya processing. A farmer-first operator, he has built the business around sustainability, technology, and bird welfare. Internationally, he served as Chairman of the World Egg Organisation — the first Asian to hold the role — and he chairs CII Animal Agriculture. His mission is simple: use poultry to end nutritional deficiency among India's women and children. Outside work, He's a wildlife photographer and conservationist with WWF.

His work has led to the company being recognised for always doing what is best for the individual farmers, industry and the country. Adopting a farmer first philosophy, he is passionate about ensuring that the poultry industry is healthy and sustainable through adoption of latest technologies, good rearing practices and welfare of the livestock. Suresh is helping the industry to be more sustainable and responsible in its production and sourcing.

Suresh is driven by the mission of eliminating nutritional deficiencies of women and children in India. He passionately advocates poultry as a vehicle of transformation and empowerment. His work has been recognised at a global level and is engaged in advocacy for the poultry industry, internationally as Chairman of World Egg Organisation (WEO). He is the first Asian to hold this position in the history of the institution.

Besides work, Suresh is active in wildlife conservation through his work with WWF and other conservation minded organizations. He is also a talented photographer and has exhibited his photographs for raising awareness and funding for conservation.

Suresh takes pride in the role he played in the two telugu states (Telangana and Andhra Pradesh) become leaders in ease of doing business, through his work in CII in various capacities. An avid reader, averaging 50 books a year, he also loves to travel and learn about different cultures and their history.

EDUCATION

Bachelor in Computer Science Engineering, RV College of Engineering, Bangalore.

Master of Business Administration, Goizueta Business School, Emory University, USA

The President's Programme in Leadership, Harvard Business School, USA

Doctoral Candidate in DBA, Golden Gate University.

Professional Affiliations & Board Memberships

Chairman, CII National Committee on Animal Agriculture

Co-Chairman Taskforce on Family Business of CII Southern Region

President (2022-2024), Chairman (2019-2022) &

Vice Chairman (2017-2019a, World Egg Organisation (WEO), U.K. Councilor for International Egg Foundation.

Co-founder of TiE Vizag Chapter.

Vice - President of All India Poultry Breeders Association.





Mr. Daljeet Singh Gill

Renowned dairy farmer and a prominent figure in the field of dairy entrepreneurship in Punjab and across India.

Educational Qualification: Graduate

Father's Name: late Sardar Maninder Singh Gill

Current Occupation: Dairy Farming (Managing a herd of over 500 cows)

Professional Summary

Mr. Daljeet Singh Gill is a renowned dairy farmer and a prominent figure in the field of dairy entrepreneurship in Punjab and across India. With over two decades of experience, he has played a transformative role in modernizing and professionalizing dairy farming practices.

He assumed leadership as the President of the Progressive Dairy Farmers Association (PDFA), Punjab, in 2002. Under his guidance, PDFA has grown into a robust organization with a membership exceeding 11000 progressive dairy farmers, each maintaining an average herd size of over 50 animals.

Mr. Gill has been instrumental in introducing and promoting innovative, sustainable, and profitable dairy farming practices. His efforts have led to a remarkable improvement in productivity and efficiency in the dairy sector in Punjab. With exposure to leading dairy industries across the globe, he has replicated best global practices and adapted them to the local context in India.

Through PDFA, he organizes monthly seminars for member farmers, featuring expert speakers in breeding, feeding, and farm management. Furthermore, he oversees the annual International Dairy and Agriculture Expo, one of India's largest exhibitions of its kind, attracting over 300,000 dairy farmers from India and neighboring countries. The expo features livestock competitions judged by international experts and showcases the latest in dairy technology and innovation.

Currently, Mr. Gill serves as the President of the All India Progressive Dairy Farmers Association (AIPDFA), where he is actively working to extend the success model of Punjab's organized dairy farms across the country.

Key Achievements:

- President, PDFA since 2002
- President, AIPDFA (All India Progressive Dairy Farmers Association)
- Managing a herd of 500 + cows
- Conducted global study tours and implemented international best practices in India
- Organizer of India's leading dairy expo, with 300,000+ annual footfall





Sumit Sureka

Managing Director : Shivshakti Agro (India) Ltd,
& Amrit Breeder Farms Pvt. Ltd,
Director: Impressico Business Solutions Pvt. Ltd.

Managing Director : Shivshakti Agro (India) Ltd, & Amrit Breeder Farms Pvt. Ltd,
Director: Impressico Business Solutions Pvt. Ltd.

Manufacturing Animal Feed Products - Poultry, Cattle, Aqua, & Pig, Poultry Breeding
Hatcheries and Broiler Integration.

School : St Paul's School, Darjeeling.

Graduation : B Com (Hons), from Shri Ram College of Commerce, Delhi.

Alumni of London Business School.

Member of YPO Calcutta Chapter since 2011.

CLFMA: Member for over 25 years, Managing Committee Member around 10 years, Office
Bearer over 8 years, and current role - Deputy Chairman for 6 years.

Vice President of West Bengal Poultry Federation

Married to **Dr Pragati Sureka** (Occupational Health Psychologist), and are blessed with two
children, **Adi** – Masters in Computers Science and **Nandini** – Graduate in Business
Administration & Psychology, who have completed their education in Boston, United States
and they have recently enrolled in the family business's.

An Avid Singer and Passionate Photographer since childhood, enjoys playing squash.





Dr Saurabh Shekhar
Managing Partner, Wipro Petcare

Dr. Saurabh Shekhar, Managing Partner, Wipro Petcare, is a seasoned business leader with over 27 years of experience across the consumer goods, animal health, and animal nutrition sectors. A veterinarian by profession, he has held diverse leadership roles spanning sales, business development, R&D, and general management across India and Southeast Asia.

Since 2022, Dr. Saurabh has been a member of the National Advisory Committee for Animal Husbandry and Dairying, constituted by the Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. In this role, he contributes to policy discussions and provides industry perspectives on animal husbandry, dairy, and fisheries, while helping strengthen collaboration between the public sector, private industry, and academia.

Dr. Saurabh is passionate about building brands and businesses, fostering innovation, and developing high-performing talent. His extensive experience with leading global family-owned businesses has equipped him with a strong entrepreneurial mindset, enabling him to build start-up businesses within large multinational organizations while creating strong organizational cultures and talent pipelines.

At Wipro, he is spearheading the establishment and growth of the Petcare business. His leadership is focused on creating a differentiated, science-led and consumer-centric Petcare business that addresses the evolving needs of pets and pet parents in India.



**Kevin Roepke**

Executive Director—Middle East, North Africa & South Asia (MENASA)
Board of Directors, US-Bangladesh Business Council

Kevin Roepke serves as the Executive Director of the Middle East, North Africa & South Asia (MENASA) for the US Soybean Export Council—the international marketing arm of US Soy.

Currently based in Dubai, UAE, Roepke leads a regional team to develop, execute and deliver the vision for differentiating, elevating preference, and enabling market access to U.S. Soy for human consumption, aquaculture, and livestock feed throughout South Asia and Sub-Saharan Africa.

Prior to this role, Roepke held similar positions, both with USSEC and the US Grains Council, covering markets in Latin America, Southeast Asia, Oceania and the PRC—having been located in Mexico, Malaysia and China.

Before his work in membership organizations, Roepke was with Archer Daniels Midland's (ADM) oilseed processing division where he was responsible for the Western Divisional soymeal export position.

He is a graduate of Iowa State University with a degree in Public Service and Administration in Agriculture, having been honored as the 2024 Young Alumni of the Year and a 2018 recipient of the STATEment Maker award. He is also the co-founder of an app that won the American Farm Bureau 2018 AgTech Startup of the Year. He received an MBA from Massachusetts Institute of Technology (MIT) in Cambridge, MA.

As a native Iowan, Roepke grew up actively involved in breeding, showing and judging livestock while in 4-H and FFA.





Mrituenjay Kumar

Distinguished Anchor and Commodity Editor at Zee Business, Zee Media

Mrituenjay Kumar Jha is a distinguished Anchor and Commodity Editor at Zee Business, Zee Media with over 20 years of experience in business journalism. He earned his Master's degree in Journalism from Makhnallal Chaturvedi National University of Journalism and Communication (2004–2006 batch).

He has been associated with Zee Business for more than 18 years, during which he has established himself as one of the country's leading business journalists. Besides anchoring business and commodity shows, he has also successfully hosted political and consumer affairs programmes. His flagship commodity programme is widely regarded as one of the most watched business news shows, attracting more than 80% of the business news television audience.

Renowned for his in-depth research, investigative reporting, and insightful market analysis, Mr. Jha has exposed several irregularities and scams in the commodity and consumer sectors. His confident presentation style, incisive questioning, and ability to engage with industry leaders, policymakers, and experts have earned him widespread recognition and respect.

In recognition of his outstanding contribution to journalism, Mr. Jha has received more than 35 prestigious awards, reflecting his excellence, credibility, and impact in the field of business journalism.





Mr. Divya Kumar Gulati

MD, Nuture Aqua Technology Pvt. Ltd. &
Chairman, CLFMA OF INDIA

Mr. Gulati brings over 30 years of extensive experience in the healthcare, nutrition and food industry. Throughout his illustrious career, he has played a pivotal role in introducing and establishing innovative and sustainable solutions that have been instrumental in changing industry standards. As the Managing Director of Nuture Technology, Mr. Gulati has not only been a pioneer in bringing the probiotic culture for shrimp farming to India in the 1990s and introducing modern farming technologies but also developed a host of innovative products through an amalgamation of ayurvedic herbal ingredients, modern technologies and extensive clinical trials that have provided the poultry and dairy industry a fresh outlook and tremendous results.

Over the past half decade Mr. Gulati has also successfully forayed into Human Healthcare and Food Industry, having set up research and production facilities that offer consumers high quality healthcare and food ingredients. As the Co-Founder of Herbs & Health and Grind Essentials, Mr. Gulati has brought his vast experience in the animal healthcare industry to the human health care space.

Mr. Gulati has also been an instrumental part of CLFMA of India for the past 12 years. Currently he is the Chairman of CLFMA of India and he has been instrumental in making in-roads into the Government Fisheries, Animal Husbandry and Dairying Ministry and Department which helped in creating a greater understanding and communication between the animal healthcare industry and the government ministry via the association. Through years of communication and relationship building with the Ministry, Mr. Gulati announced the launch of the CLFMA Students Program at this year's symposium. This unique initiative invites students across the country to present research projects addressing real-world challenges in poultry, dairy, swine, and aquaculture sectors creating pathways for youth involvement and innovation in animal agriculture. He remains steadfast in championing the interests of livestock farmers and sector players by promoting sustainable practices, facilitating knowledge exchange, and supporting policies that strengthen India's livestock economy. Our efforts focus on enhancing productivity, animal health and welfare, food safety, and the adoption of advanced technologies to meet evolving consumer and market demands, through various seminars and farmers' orientation programs. His deep understanding of industry needs and government policies, relationship building skills, and his forward-thinking approach have earned him the respect and admiration of colleagues, peers, and competitors alike.





Mr. Ranpal Dhanda

Associated with the Poultry Sector

Mr. Ranpal Dhanda has been associated with the poultry sector for over three decades. He began his career as a small poultry farmer and today is counted among the leading poultry entrepreneurs in the country. Presently, he operates several feed mills, breeding farms, poultry farms, and a state-of-the-art slaughterhouse. In addition to poultry, he is also successfully engaged in various other businesses across India.

Mr. Dhanda has been actively involved with the Poultry Federation of India for many years and has been serving as its President since 2021. Under his leadership, the Federation has undertaken several significant initiatives for the welfare of the poultry sector and has played a pivotal role in giving the industry a new direction.

Notably, Mr. Dhanda has consistently worked toward empowering small and medium poultry farmers. His vision, dedication, and leadership have strengthened the poultry industry and laid the foundation for a brighter future.





Shri Uday Singh Bayas

President – IPEMA / Poultry India

Managing Director – Vijayraj Poultry Equipment Pvt. Ltd.

Present Industry Positions

- **President – Indian Poultry Equipment Manufacturers' Association (IPEMA) / Poultry India**
- **Managing Director – VijayRaj Poultry Equipment Pvt. Ltd.**
- **Working Committee Member – CII - National Committee on Animal Agriculture.**
- **Working National Board Council Member – ASSOCHAM for 5 States.**
- **Sub-Committee Member, Organizing Committee of the Exhibitions – Indian Exhibition Industry Association (IEIA)**

PROFILE & LEADERSHIP

Mr. Uday Singh Bayas is a prominent poultry industry leader with **over three decades of experience** in poultry equipment manufacturing, international business, industry development, exhibitions, and technology advancement. He joined VijayRaj Poultry Equipment Pvt. Ltd. in **1994** and played a key role in its transformation from a domestic manufacturer into an internationally recognized poultry equipment company, with turnkey projects and equipment supplied across **Africa, the Middle East and South America.**

An alumnus of **Osmania University**, he completed his management studies at **Shiv Shivani Institute of Management**, affiliated with Jawaharlal Nehru Technological University.

PRESIDENT – IPEMA / POULTRY INDIA | 2023 – PRESENT

Since becoming **President in 2023**, Mr. Bayas has led IPEMA / Poultry India through a period of significant growth and international expansion. His leadership has focused on strengthening global partnerships, promoting innovation and technology, enhancing industry collaboration, and positioning Poultry India as a leading platform for **business, knowledge-sharing, networking and international engagement.**

KEY ACHIEVEMENTS UNDER HIS PRESIDENCY

- **16th Poultry India Expo 2025:** Over **400 exhibitors, 40,000+ visitors and participation from 50+ countries.**
- **17th Poultry India Expo:** Expanded to **550+ exhibitors and 51,000+ industry professionals from 110+ countries expected**, reflecting the growing global stature of the platform.
- Strengthened **international associations, trade delegations, exhibitors and industry partnerships.**
- Expanded Poultry India beyond an exhibition through **technical seminars, leadership summits, innovation showcases, student engagement and international collaborations.**
- Promoted **automation, advanced poultry technologies, modern housing, feed efficiency, biosecurity and sustainable production.**
- Encouraged greater participation of **MSMEs, young entrepreneurs and emerging poultry professionals.**
- Supported **rural and backyard poultry development**, helping extend modern poultry solutions to underserved communities and promote sustainable livelihoods.

VISION

Mr. Bayas believes in building a **future-ready, technology-driven, sustainable and globally connected poultry ecosystem.** His leadership philosophy is rooted in **innovation, discipline, collaboration, knowledge-sharing and inclusive growth**, bringing together farmers, manufacturers, breeders, feed companies, veterinarians, processors, researchers, policymakers and international stakeholders.

Through his continued leadership, **IPEMA / Poultry India is strengthening India's position on the global poultry map and creating new opportunities for innovation, investment, collaboration and sustainable growth across the poultry value chain.**





Madan Mohan Maity
General Secretary, WBPFA

- **General Secretary, West Bengal Poultry Federation** – Constituted by the Government of West Bengal in 2009, the Federation monitors and facilitates the development and reorganization of poultry production in the state since inception, 2009.
- **Zonal Chairman, National Egg Coordination Committee (NECC), India** – Kolkata/West Bengal Zone, from 1994.
- **Managing Director, Maity Animal & Avian Nutrition Pvt. Ltd.** – A leading poultry and cattle feed production company in West Bengal.
- **Chairman & Managing Director, Maity Poultry Group of Companies** – The group is engaged in Direct poultry farming, breeding, and a wide range of poultry-related activities. It has introduced modern international techniques and hygienic layer poultry farming practices in West Bengal and is the largest producer of table eggs (including value-added eggs) in Eastern India. since 1990

Additional Roles & Contributions

- **Executive Council Member, West Bengal University of Animal and Fishery Sciences, Kolkata.**
- **Chairman, Midnapore Rotary Eye Hospital** – Providing affordable and quality eye care services to underserved communities and engaged in best eye care services to affordable people in south Bengal,
- **Rotarian** since 1994 – Held several key positions including *Assistant Governor*, Rotary District 3291.
- **Former Member, State Agriculture Commission, Government of West Bengal.**
- **Secretary, Kumarpur Arabindo Jana Kalyan Sanstha** – An organization focused on the formation and development of Self-Help Groups (SHGs) for underprivileged communities. Established in the early 1990s and actively functioning in Paschim Medinipur district.





Saji Chacko

Seasoned Aquaculture Entrepreneur and
Shrimp Farmer

Saji Chacko is a seasoned aquaculture entrepreneur and shrimp farmer with over three decades of practical experience across India's coastal farming sector. Currently serving as the President of the Society of Aquaculture Professionals (SAP) for the 2025–2027 term, he plays a key leadership role in uniting farmers, technical experts, and industry stakeholders to promote sustainable farming practices, robust biosecurity standards, and farmer welfare.

As a partner at Poseidon Enterprises, he brings extensive field expertise in commercial shrimp production, disease mitigation, and farm management. Beyond on-ground operations, he actively contributes to national policy dialogues, technical forums, and industry crop reviews, offering actionable insights to address ground-level challenges and strengthen aquaculture value chains.

Based in Gujarat, he remains dedicated to advancing scientific pond management and knowledge-sharing within the farming community. His ongoing focus is on building resilient production systems, encouraging modern methodologies, and enhancing the long-term sustainability of the Indian aquaculture sector.





R. Ramkutty

Managing Director of Niswin Enterprises & Treasurer
of CLFMA OF INDIA

R. Ramkutty is the Managing Director of Niswin Enterprises, a diversified business group headquartered in Coimbatore, India, with a turnover exceeding ₹300 crores.

A seasoned marketing professional with over 30 years of experience across pharmaceuticals, food products, and exports, he began his career at Nicholas Pharmaceuticals and later held leadership roles at Leaders Bangalore and Sakthi Sugars.

An MBA graduate from PSG College of Technology, he combines business acumen with a passion for academia, serving as a visiting faculty and board member at several institutions.

Mr. Ramkutty is actively engaged in public life through Rotary, Sports associations, and Industry bodies such as CII, CLFMA OF INDIA (Association of Livestock Sector), and SOPA. His global exposure and commitment to education and philanthropy underscore his multifaceted contributions to society.





Bhaskar Karampudi

Co-founder & Director

- Co-founder and Director of B-CUBE Consulting Private Limited
- Bhaskar Karampudi is a senior management professional, trainer and entrepreneur with over 32 years of experience across pharmaceuticals, telecom, mining, IT/ITES, e-learning, education, non-profits, EdTech and FinTech. An MBA in Human Resources
- An alumnus of IIM Kashipur, he previously served as Head of HR and Learning & Development at Dr. Reddy's Foundation.
- In recent years, Bhaskar has focused extensively on helping organisations understand and adopt Artificial Intelligence in practical and measurable ways. He conducts AI awareness programmes, leadership sessions, faculty development programmes and hands-on workshops covering generative AI, prompt engineering, content creation, research, productivity enhancement and workplace applications.
- Through B-CUBE, he also provides consulting and implementation support for AI-driven workflow automation, process optimisation and digital transformation.
- Bhaskar leads a multidisciplinary network of 53 trainers and 17 technical consultants, enabling B-CUBE to deliver AI training, consulting and implementation services both online and offline to organisations in India and overseas. His approach combines management experience, training expertise and technology implementation to help organisations translate AI possibilities into practical business outcomes.





Mr. Shrivardhan Vaman Bhave

Berg and Schmidt India Pvt. Ltd. as Managing Director
Hightech Energy Feeds India Pvt. Ltd. as Director.

Mr. Shrivardhan Vaman Bhave is a graduate with Physics and Mathematics and has over two decades of extensive experience in the oils, fats and lipids sector, with a particular focus on the animal feed industry.

He is associated with **Berg and Schmidt India Pvt. Ltd.** as Managing Director and **Hightech Energy Feeds India Pvt. Ltd.** as Director. Through these organizations, he has been actively involved in the manufacturing, marketing and distribution of animal feed fats, speciality fats and oleochemicals across India, Nepal, Bangladesh and Sri Lanka.

Mr. Bhave has played a pioneering role in introducing innovative lipid-based nutritional solutions to the Indian animal feed industry. He introduced the **bypass fat concept in the Indian dairy industry in 1998** and subsequently introduced the latest-generation **nano-matrix technology-based value-added fat powder in the Indian market in 2016**.

His areas of expertise include palm- and soya-lecithin-based functional fats for animal feed, high-purity lipids and short-chain triglycerides.

Mr. Bhave has been closely associated with **CLFMA OF INDIA** for several years, having served as a Managing Committee Member and Deputy Chairman for nearly 12 years. He has also served as the **Chairman of CLFMA OF INDIA** and continues to be associated with the organization as its Past Chairman, an honorary position.

In addition, he has been associated with the **German Chambers of Commerce** for the past 18 years.

With his long-standing experience and pioneering contributions to the animal nutrition and feed industry, Mr. Shrivardhan Vaman Bhave is widely recognised for his expertise in speciality lipids and innovative feed-fat technologies.





Dr. Mahesh Subhash Patlapati

B.V.Sc., M.V.Sc., PGPPM (IIMB)

- **Dr. Mahesh Subhash Patlapati**, hails from Chitradurga, Graduated in Bengaluru as **Post Graduate in Veterinary Virology**, Management Graduate from Indian Institute of Management, Bangalore (**IIMB**), a premier Institute of Management in India. Worked in various capacities in Private Sector, Autonomous Institutions, State and Central Animal Husbandry Sectors of India.
- Presently serving as **Joint Commissioner & Director of Centre of Excellence for Animal Husbandry (CEAH)**, Government of India, a premier Academy for Animal Husbandry in India since 1st April 2023.
- Represented India in USDA during 2012, in VIV Europe in 2018 and delivered talks. Dr. Mahesh addressed at **German – Indo Meat Mission** round table at Bengaluru during December, 2018.
- Dr. Mahesh is an **invited Lead Speaker in various National Forums** viz., CII, FICCI, Engineering, Medical Universities, Science and Business Schools on various topics of National Interest. Apart from this, he is a lead speaker in Animal Husbandry Sector on topics of Dairy, Poultry Economics in the country.
- Dr. Mahesh is an **Advisory Member to various Veterinary Universities** of Tamilnadu, Kerala and Karnataka. Expert Member of various Committees, Bureau of Indian Standards (**BIS**), FAD-18, National Bank for Agriculture and Rural Development (**NABARD**), Agricultural Skill Council of India (**ASCI**) and Institution of Veterinarians of Poultry Industry (**IVPI**).
- Dr. Mahesh is chosen as a **Group Leader** for Inter-ministerial Central Team (**IMCT**) for drought assessment in Karnataka during November, 2018 touring 7 districts with Collectors.

- **Chief Liaison Officer** representing Department of AH&D, Govt. of India for **Loksabha and Rajyasabha** committees during 2021.
- **Chief Guest for convocations** at GCC, HKBK, NSBA and IIBS, MBA colleges at Bengaluru.
- Dr. Mahesh has received various awards on National and International repute. Dr. Mahesh conducts Podcasts of Heroes of Animal Husbandry Sector @Ceah Bengaluru Academy.



Thank you... Scan to get linked





Dr. Gagan Garg

Joint Commissioner
Ministry of Fisheries, Animal Husbandry and Dairying
Department of Animal Husbandry and Dairying

Professional Experience:

- More than 11 years' experience in State Animal Husbandry Department, Government of Rajasthan
- More than 14 years' experience in Department of Animal Husbandry and Dairying, Government of India, which includes;
 - Policy matters related to drafting and implementation of schemes at country level for production enhancement and employment generation in livestock sector viz. cattle, buffalo, small ruminants, piggery, poultry, equines etc.
 - Regulation of international trade in the country for livestock and livestock products including;
 - (i) Regulation of international trade in the country for Biologicals and animal feed additives/supplements
 - (ii) Negotiations / aligning of veterinary health protocols based upon International SPS norms as per World Organization for Animal Health and scientific rationale for mutual trade / market access between the countries
 - (iii) Negotiations on tariff and non-tariff measures under Bilateral / Regional/Multilateral Foreign Trade Agreements
 - (iv) Risk Analysis for issuance of Sanitary Import Permits for import of livestock products including poultry & fishery products into India
 - (v) Risk Analysis for recommending import of live animals including wildlife and laboratory animals
 - (vi) Co-ordination with International Bodies on policy, planning and maintenance of Livestock Health and Trade
 - (vii) Audit of establishments exporting livestock products
 - (viii) Bilateral co-operation related to livestock & livestock products
 - (ix) Trade facilitations through the Animal Quarantine and Certification Service Stations under National Trade Facilitation Action Plan
 - Policy drafting, planning and implementation of livestock related schemes on all India level





Prof. (Dr.) Pankaj Kumar Shukla

Professor and Head, Department of Poultry Science,

Prof. P. K. Shukla, Professor and Head, Department of Poultry Science, U. P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwa Vidyalaya Evam Go Anusandhan Sansthan, DUVASU, Mathura (U.P.), India is graduate of Veterinary College Jabalpur. He obtained M.V.Sc. in Poultry Science from Indian Veterinary Research Institute, Izatnagar. and Ph.D. in Poultry Science from Chandra Shakhazad University of Agriculture and Technology, Kanpur. He has been decorated with numerous prestigious awards and honors including "Best Outgoing Graduate Award", "Rastropati Award" in Scouting, "Life Time Achievement Award" by CLFMA, "Life Time Achievement Award" by Govt. of India, "Life Time Achievement Award" by Agriculture Today, "Distinguished Faculty Award" by Venus International Foundation, Chennai, "Deputy Director General, NCC, Uttar Pradesh Appreciation Award", Lifetime Achievement Award by Pashudhan Prahari, Certificate of Excellence Award by Indian Poultry Review, Poultry Legend Award in Padamshree DrB.V.Rao Poultry Entrepreneurs Global Icon Award 2020.etc.

Prof. Shukla is distinguished fellow of National Academy of Veterinary Sciences and National Academy of Veterinary Nutrition and Animal Welfare. He had been the Member Secretary of the prestigious "Central Poultry Development Advisory Council of Government of India, Member "Joint Working Group" under MOU signed between India and Uganda on the co-operation in the field of agriculture and Allied sector, Member, "Joint Monitoring Group" Of Govt. of India for Avian Influenza of Ministry of Agriculture & Ministry of Health and Family Welfare, Chairman, Committee on Bilateral issues during New Delhi International Ministerial Conference on Avian and Pandemic Influenza, Member, Rural Advisory Committee of Doordarshan, Mandi House New Delhi, Member, Breed Registration "Committee for Registration of Poultry Breed" in Indian Council of Agricultural Research, Member of Research Advisory Committee of Central Avian Research Institute, Izatnagar and Project Directorate on Poultry, Rajendra Nagar, Hyderabad, Member, QRT for Indian Veterinary Research Institute, Izatnagar, Member, National Advisory Committee for Animal Husbandry

and Dairying Sector of Ministry of Fisheries, Animal Husbandry and Dairying, Government of India Chaired by Union Minister of Fisheries, Animal Husbandry and Dairying, Government Of India, Chairman, Scientific Panel on Meat and Meat Products including Poultry of FSSAI, Advisor, Agriculture Skill Council of India for Poultry Development, Member Board of Management, RAJUVAS, Bikaner, Member, Academic Council, NDVSU, Jabalpur, Member, Academic Council, ICAR-IVRI, Izatnagar, Member, Academic Council, BASU, Patna, etc.

Earlier Professor Shukla worked as Dean, College of Veterinary Science and Animal Husbandry, U. P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwa Vidyalaya Evam GoAnusandhan Sansthan, DUVASU, Mathura, Scientific and Technical Advisor to Vice Chancellor, DUVASU, Mathura. He worked as Joint Commissioner (Poultry), Government of India in Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi from May 2007 to April 2012, playing a crucial role in the Policy, Planning & Program implementation especially in Poultry Sector. He also served as Dean Post Graduate Studies, and Registrar, DUVASU, Mathura. He believes in dissemination of relevant information amongst various stake-holders and has about 316 publications in his credit besides 4 books 13 book chapters and two laboratory manuals. He has guided more than 30 M.V. Sc. And Ph.D. students. He authored several Policy Papers and Status Papers and is on the editorial boards of several journals and magazines of repute. Presently Prof. P.K. Shukla is engaged in research and education management in veterinary science and providing leadership for overall Poultry development in country.





Mr. Naveen Pasuparth
Bangalore-based “Chief Farmer”,

Mr. Naveen Pasuparth is a Bangalore-based “Chief Farmer”, engaged in animal agriculture, with interests in building a consumer brand, spatial technology ventures and emerging solutions such as insect protein.

A Kannadiga by birth, he holds a **B. Com from Bangalore University** and an **MBA from Rutgers University, USA**. A salesman by heart, he began his professional career in the US before returning to India in 1996 and joining his family business, **Nanda Group**.

The Group is engaged in poultry breeding, poultry hatcheries, animal feed manufacturing, poultry disease diagnostics labs, raw material testing labs, commercial broiler and commercial layer integration models, processing, manufacturing of ready-to-eat and ready-to-cook products, and omni-channel meat retailing (D2C) under the consumer brand “Nandus”, with 1.6 million customers and growing. He has contributed to the Group's expansion across India, Oman, UAE and Nigeria.

On the sectoral front, Mr. Pasuparth has served as Treasurer of CLFMA of India and Karnataka Poultry Farmers & Breeders Association (KPFBA) since 2013. **He is the sitting Dy Chairman, CLFMA of India, & President of Karnataka Poultry Farmers & Breeders Association (KPFBA).**

During his tenure, he has actively led:

- Executing a 24,000 poultry farmers conclave with the Government of Karnataka.
- Creating a video on the “Contribution of Poultry Sector” to rural India and crop agriculture.
- Policy advocacy with the State and Federal Governments.
- Creating the concept, “One Sector, One Voice”, for the State and Federal Governments.
- Getting the next generation of poultry leaders together under “I don't have data, I have friends”.
- Creating awareness about the **Animal Husbandry Infrastructure Development Fund (AHIDF) across the poultry sector.**

- Executing a crowd-funded activity using scientific and technology-driven, data-driven solutions to monitor maize and soybean production in India.
- An initiative, as part of CLFMA, in successfully getting the Indian Government's approval for the import of **1.5 million tonnes of soybean meal into India.**

Beyond business & his contribution to the sector, Mr. Pasuparthi is actively engaged as:

- Trustee of RV Educational Institutions.
- Governing Council Member, APS College.
- Governing Council Board Member, Canara Bank Deshpande Rural Self Employment Training Institute, Haliyal, Karnataka.
- Member of Entrepreneurs' Organization (EO), Bengaluru, for the last 23 years.

He was also featured in Forbes India in 2022.





Dr. Ajay Deshpande

Managing Director, Siddivinayak Breeding Farms Pvt. Ltd.
President, Vets In Poultry (VIP)

Dr. Ajay Deshpande is a distinguished poultry veterinarian, entrepreneur, and industry leader with more than three decades of experience in poultry breeding, production, technical services, consultancy, and broiler integration.

Dr. Deshpande completed his schooling in **Udgir, Latur district**, and graduated in **Veterinary Science from Maharashtra Animal & Fishery Sciences University (MAU), Parbhani, in 1992.**

He began his professional career in 1992 with **Tarkeshwara Hatcheries Pvt. Ltd.**, a pure-line poultry breeding company working with broiler purelines of **Anak 2000** and layer purelines of **H&N**. During his tenure, he had the opportunity to work under the guidance of eminent poultry professionals including **Dr. Solanki, former Professor of Pathology at Bombay Veterinary College, Dr. Anil Phadke, and Dr. Kotaiah, Chief Geneticist.**

Starting as a **Trainee Veterinary Officer**, he progressed through various responsibilities, including **Farm Manager, General Manager – Production, and General Manager – Technical Services.** In his technical services role, he provided professional support to associate companies of Tarkeshwara Hatcheries, particularly across **South India.**

In 2000, Dr. Deshpande ventured into independent consultancy, providing technical services and guidance to breeder and broiler farmers.

His entrepreneurial journey in poultry farming began in **2004**, when he established his own breeder farm in partnership with **Indbro (originally Indian River)** on a rented farm. In 2006, his business faced a major setback following the **Navapur bird flu declaration**, when he had approximately **14,000 breeders in lay.** Despite this significant challenge, he rebuilt the business with the support of banking institutions, while taking on additional financial responsibilities.

In 2007, he shifted from Indbro to **Cobb** and subsequently joined hands with the promoters of **Yojana Poultry, led by Mr. Raju Bhosale**, forming a partnership firm.

Under his leadership, the breeder farming business underwent significant expansion, reaching a capacity of approximately **1 lakh laying birds by 2011**.

In 2013, Dr. Deshpande expanded into **contract broiler farming and integration**. Over the years, he has developed a sizeable broiler integration business across Maharashtra, further establishing his presence as an entrepreneur and industry professional.

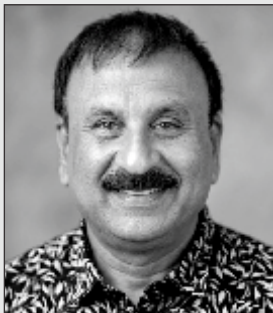
Today, Dr. Ajay Deshpande serves as the **Managing Director of Siddivinayak Breeding Farms Pvt. Ltd.** and is the **President of Vets In Poultry (VIP)**. His professional journey reflects a combination of strong veterinary expertise, hands-on poultry experience, entrepreneurship, resilience, and a sustained commitment to the growth and development of the poultry industry.

Professional Journey at a Glance

- 1992: Graduated in Veterinary Science, MAU, Parbhani
- 1992–2000: Tarkeshwara Hatcheries Pvt. Ltd.
- 2000: Started independent poultry consultancy
- 2004: Established own breeder farming operation
- 2007: Shifted to Cobb breeding program
- 2011: Expanded breeder farming to ~1 lakh laying capacity
- 2013: Entered contract broiler farming and integration
- Present: MD, Siddivinayak Breeding Farms Pvt. Ltd.
- Present: President, Vets In Poultry (VIP)

Dr. Ajay Deshpande's journey from a young veterinary graduate to a successful poultry entrepreneur and industry leader is a story of perseverance, continuous learning, and commitment to the poultry sector.





Valsan Parameswaran

Managing Director of Sathyam Farms Pvt Ltd,

Valsan Parameswaran is an eminent agribusiness leader, trade strategist, and policy expert who seamlessly bridges the gap between livestock science, macro economics, and international trade networks. An MBA graduate by academic training, he leverages advanced corporate strategy as the Managing Director of Sathyam Farms Pvt Ltd, a large-scale commercial layer poultry farm, and Logical Agribusiness India Pvt Ltd. Within the livestock feed sector, he has pioneered major nutritional innovations, introducing high-grade European-standard phosphate additives that optimize feed efficiency, reduce traditional bulk feed volume inputs by up to 40%, and drastically lower overhead production costs for commercial livestock farmers.

His extensive background in agricultural supply chain crisis management is anchored by a proven track record of resolving massive structural shocks and working closely with premier regulatory bodies. He regularly collaborates with the Agricultural and Processed Food Products Export Development Authority (APEDA) and the Export Inspection Council (EIC) to enforce international quality compliance, streamline trade certifications, and clear export logjams. Leveraging this technical expertise, he actively advises the industry on setting up advanced compartmentalised poultry farms, creating biosecure, disease-isolated zones that meet strict EIC and APEDA export protocols. This strong regulatory framework was central to his recent geopolitical intervention, where he coordinated with the Government of India to secure the release of 125 containers of eggs stuck in Gulf waters due to the Strait of Hormuz crisis. By leading emergency meetings across APEDA, EIC, the Ministry of Shipping, the Ministry of Commerce, and the Department of Animal Husbandry, and directly persuading the governments of Oman and the UAE, he successfully navigated complex diplomatic deadlocks to release every single container. This builds on his historic crisis leadership during the 2007 Avian Influenza outbreak, where he served as the Nodal Officer to execute the emergency

distribution of 2 lakh (200,000) tonnes of maize across poultry sectors to stabilize regional feed security.

At the national and regional regulatory levels, he serves as a Central Executive Committee Member of the National Egg Coordination Committee (NECC) and an Executive Committee Member of the Tamil Nadu Poultry Farmers Association (TNPFA), directly shaping wholesale market benchmarks [NECC]. Globally, he serves as the Secretary of the All India Poultry Product Exporters Association (AIPPEA), where he oversees the cold-chain logistics and biosecurity frameworks required to export over 5 million eggs daily from Namakkal to the GCC [AIPPEA]. His persistent trade diplomacy includes successfully capitalizing on Free Trade Agreements to ensure duty-free access while continuously leading compliance talks to unlock new global frontiers like Russia, ensuring the long-term sustainability of India's compound livestock feed and farming industries.





Mr. Abhay Shah

Chemical Engineer from
R.V. College of Engineering,

Mr. Abhay Shah is a Chemical Engineer from **R.V. College of Engineering, Bangalore**, and holds a **Master's degree in Food Technology from the University of Georgia, Athens, Georgia, USA**. He began his professional career in the United States, where he spent five years gaining experience in the **Poultry and Baking industries**. He has been associated with **Spectoms Engineering Pvt. Ltd. (SEPL) for the past 16 years** and currently serves as its **Joint Managing Director**, where he leads the company's Feed Industry Projects. Over the years, he has been closely involved in the development and execution of diverse processing projects across the feed and allied industries, bringing together his engineering, food technology and industry experience.

Mr. Shah has been actively associated with **CLFMA of India for over fourteen years**, during which he has served on the Managing Committee and as an Office Bearer, including **General Secretary for two years and Deputy Chairman for the past two years**. He has made a significant contribution to the Association's outreach and industry engagement, particularly through his active involvement in the **Public Relations Committee**, where he has played an instrumental role in strengthening CLFMA's visibility and communication. His association with CLFMA reflects his commitment to the growth of the animal agriculture and feed industry and to fostering greater collaboration and dialogue across the sector.

He currently serves as **Deputy Chairman, CLFMA of India**, and will deliver the Valedictory Session at the **67th National Symposium 2026**.



ANIMAL AGRICULTURE: THE BACKBONE OF SUSTAINABLE DEVELOPMENT

Prof. (Dr.) P.K. Shukla

Introduction

Animal agriculture has been an indispensable component of human civilization for thousands of years, evolving from traditional subsistence farming into a highly scientific, technology-driven sector that supports global food systems and economic development. Today, livestock production encompasses dairy farming, poultry production, sheep and goat farming, piggyery, aquaculture, and allied industries such as feed manufacturing, veterinary healthcare, breeding, biotechnology, meat processing, and value-chain logistics. Collectively, these activities generate employment, enhance food security, and contribute significantly to national economies.

The concept of sustainable development, popularized by the Brundtland Commission in 1987, emphasizes meeting present needs without compromising the ability of future generations to meet their own. Sustainable development rests on three interconnected pillars: economic viability, environmental protection, and social equity. Animal agriculture contributes meaningfully to all three by generating income, supplying nutrient-rich food, supporting rural livelihoods, recycling nutrients, and fostering resilient farming systems.

Globally, livestock contributes approximately 40% of agricultural GDP and supports the livelihoods of nearly 1.3 billion people. In India, the livestock sector contributes around one-third of agricultural Gross Value Added and has consistently recorded higher growth rates than the crop sector. The country ranks first in milk production, is among the world's largest producers of eggs and poultry meat, and possesses one of the richest repositories of indigenous livestock genetic resources.

Unlike crop farming, which is seasonal and

vulnerable to weather fluctuations, livestock production provides regular income throughout the year. Milk is marketed daily, eggs are produced continuously, and poultry production offers rapid turnover. Consequently, livestock serves as a financial buffer against crop failures, market instability, and climatic uncertainties, particularly for smallholder and marginal farmers.

The role of animal agriculture extends beyond food production. Livestock converts crop residues and agro-industrial by-products into valuable animal protein, produces organic manure that improves soil fertility, supplies renewable energy through biogas, and strengthens integrated farming systems. These contributions make livestock an integral component of circular agriculture and sustainable bioeconomy.

However, increasing concerns regarding greenhouse gas emissions, biodiversity conservation, water use, antimicrobial resistance, and animal welfare have intensified the need for transforming conventional livestock production systems. Scientific innovations such as precision livestock farming, climate-smart agriculture, genomic selection, renewable energy integration, and digital technologies provide promising pathways for achieving sustainable livestock development.

Animal Agriculture and Food Security

Food security is achieved when all people have physical, social, and economic access to sufficient, safe, and nutritious food at all times. Animal agriculture contributes directly to each of these dimensions by providing a continuous supply of nutrient-rich foods while generating income that enables households to access diverse diets.

Animal-source foods—including milk, meat, eggs,

and fish—are rich in highly digestible proteins, essential amino acids, vitamins, and minerals that play vital roles in human growth, immunity, and cognitive development. Milk supplies calcium, phosphorus, and vitamin B₁₂; eggs provide high-quality protein, choline, and essential fatty acids; while meat contributes haem iron, zinc, selenium, and vitamin B₁₂. These nutrients are particularly important for pregnant women, infants, children, adolescents, and older adults.

Protein-energy malnutrition and micronutrient deficiencies remain significant public health concerns in many developing countries. The inclusion of moderate quantities of animal-source foods in balanced diets has been associated with improved child growth, enhanced cognitive performance, stronger immune function, and better maternal health outcomes.

Livestock also contributes indirectly to food security through biological conversion of non-edible biomass into edible food. Ruminants efficiently utilize grasses, crop residues, and fibrous agricultural by-products that humans cannot digest, converting them into nutritious milk and meat. Similarly, poultry and pigs utilize various feed ingredients and food industry by-products with remarkable efficiency, thereby increasing overall resource-use efficiency within food systems.

The poultry industry exemplifies sustainable intensification through rapid genetic improvement, superior feed conversion efficiency, and short production cycles. Broiler chickens require comparatively less feed and water per kilogram of edible protein than many other terrestrial livestock species, making poultry an increasingly important component of affordable nutrition.

Livestock, Rural Livelihoods, and Inclusive Economic Growth

Animal agriculture is one of the most effective instruments for rural development and poverty reduction. Livestock ownership provides financial security, regular income, employment, and resilience against agricultural risks. For millions of smallholder farmers, dairy animals, goats, sheep, pigs, and backyard poultry represent valuable productive assets that can be sold during emergencies or utilized to generate regular household income.

The livestock sector creates employment throughout its value chain, including breeding, feed production, veterinary services, diagnostics, processing, transportation, retailing, and exports. Rapid expansion of dairy cooperatives, poultry integration, feed industries, vaccine production, biotechnology, and livestock processing has generated substantial employment opportunities for both skilled and unskilled workers.

Women play a central role in livestock production, particularly in dairy farming and backyard poultry. Their participation improves household income, nutrition, financial inclusion, and decision-making power. Livestock development programmes targeting women and self-help groups have demonstrated significant success in enhancing economic empowerment and reducing rural poverty.

Livestock also supports landless labourers and marginal farmers because animal husbandry requires relatively limited land compared to crop production. Integrated crop–livestock farming further improves resource utilization by recycling crop residues as animal feed and returning manure to agricultural fields, thereby increasing productivity while reducing production costs.

Animal Agriculture and Environmental Sustainability

Animal agriculture is increasingly recognized not only as a food-producing sector but also as a key component of sustainable natural resource management. Well-managed livestock systems contribute to nutrient recycling, soil fertility, biodiversity conservation, renewable energy generation, and the efficient utilization of agricultural by-products. Although concerns regarding greenhouse gas emissions and resource use are valid, scientific evidence indicates that sustainable livestock management can substantially reduce environmental impacts while enhancing ecosystem services.

One of the greatest environmental advantages of livestock is its ability to convert crop residues, grasses, agro-industrial by-products, and other non-edible biomass into highly nutritious food. Ruminants efficiently digest fibrous plant materials that cannot be consumed directly by humans, thereby transforming low-value biomass into milk

and meat. This biological conversion significantly improves resource-use efficiency within agricultural systems and reduces food waste.

Animal manure is another valuable resource. Rich in organic matter and essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients, manure enhances soil fertility, improves soil structure, increases microbial activity, and promotes carbon sequestration. Regular application of well-managed organic manure reduces dependence on chemical fertilizers, lowers production costs, and improves long-term soil health.

Integrated crop–livestock systems exemplify environmental sustainability by creating closed nutrient cycles. Crop residues become livestock feed, while manure returns nutrients to agricultural fields. Such systems reduce external inputs, improve productivity, and enhance resilience against climatic and market uncertainties. In rainfed and resource-poor regions, these integrated models offer a sustainable pathway for increasing farm income while conserving natural resources.

Livestock also contributes to maintaining grassland ecosystems. Scientifically managed grazing improves forage productivity, prevents shrub encroachment, promotes biodiversity, and enhances soil carbon storage. Rotational grazing and silvopastoral systems, which integrate trees, pasture, and livestock, have emerged as effective strategies for balancing productivity with ecological conservation.

Thus, the environmental sustainability of animal agriculture depends not on livestock numbers alone but on efficient management, scientific innovation, and responsible stewardship of natural resources.

Circular Bioeconomy and Resource Recycling

The transition from a linear economy to a circular bioeconomy has become a global priority for achieving sustainable development. Animal agriculture occupies a central position within this framework because livestock systems naturally recycle biological resources and convert agricultural wastes into economically valuable products.

In a circular livestock production system, virtually every output becomes an input for another process.

Crop residues, damaged grains, fruit and vegetable wastes, distillers dried grains with solubles (DDGS), oilseed cakes, and agro-industrial by-products are efficiently utilized as livestock feed. This minimizes waste while reducing competition between food and feed resources.

Similarly, livestock manure serves multiple purposes. Besides its role as an organic fertilizer, manure is increasingly used for biogas production through anaerobic digestion. Biogas provides renewable energy for cooking, electricity generation, and heating, while the residual slurry is an excellent biofertilizer rich in nutrients and beneficial microorganisms. Such integrated systems reduce greenhouse gas emissions, improve nutrient recycling, and enhance farm profitability.

The concept of "waste-to-wealth" has gained prominence in livestock production. Poultry litter can be processed into organic fertilizers, compost, and biochar, while slaughterhouse by-products are utilized in pharmaceuticals, collagen production, pet food, leather processing, and industrial applications. These innovations create additional income streams while minimizing environmental pollution.

Circular bioeconomy approaches are particularly relevant for countries like India, where millions of mixed farming systems already operate on principles of resource recycling. Strengthening these systems through technological interventions, improved waste management, and value addition will significantly enhance the sustainability of animal agriculture.

Climate-Smart Animal Agriculture

Climate change poses one of the greatest threats to global livestock production. Rising temperatures, erratic rainfall, droughts, floods, and extreme weather events adversely affect feed availability, water resources, reproductive performance, animal health, and productivity. Consequently, the concept of Climate-Smart Animal Agriculture (CSAA) has emerged as a comprehensive strategy to enhance resilience while reducing environmental impacts.

Climate-smart livestock systems pursue three interconnected objectives: increasing productivity, strengthening adaptation to climate change, and mitigating greenhouse gas emissions. These objectives are achieved through improved genetics,

efficient feeding, sustainable pasture management, renewable energy integration, and precision livestock management.

One important adaptation strategy is the development and conservation of heat-tolerant livestock breeds. Indigenous breeds often possess superior adaptability to local climatic conditions, disease resistance, and lower maintenance requirements. Their conservation and genetic improvement are therefore essential components of climate resilience.

Improved housing design also contributes significantly to climate adaptation. Adequate ventilation, thermal insulation, evaporative cooling systems, misting devices, and energy-efficient housing reduce heat stress and improve animal welfare. In poultry production, environmentally controlled housing systems have substantially improved productivity while minimizing climatic risks.

Feed management is another critical component of climate-smart livestock farming. Precision nutrition, balanced rations, improved forage quality, and methane-reducing feed additives enhance feed conversion efficiency while lowering greenhouse gas emissions per unit of animal product.

Modern weather forecasting, remote sensing, and decision-support systems enable farmers to anticipate climatic risks and adopt timely management interventions. Such technologies improve farm resilience and reduce production losses associated with climate variability.

Climate-smart livestock production therefore represents a balanced approach that simultaneously supports food security, farmer livelihoods, and environmental sustainability.

Precision Livestock Farming and Digital Transformation

The rapid advancement of digital technologies has ushered in a new era of Precision Livestock Farming (PLF), transforming conventional livestock management into a highly data-driven enterprise. PLF integrates artificial intelligence (AI), the Internet of Things (IoT), machine learning, sensors, robotics, drones, and cloud computing to monitor animals continuously and optimize production efficiency.

Wearable sensors attached to animals monitor physiological and behavioural parameters such as body temperature, heart rate, rumination, feed intake, water consumption, locomotion, and reproductive behaviour. Artificial intelligence analyses these data in real time, enabling early disease detection, precision feeding, estrus prediction, and timely veterinary intervention.

Automated milking systems, robotic feeders, climate-controlled poultry houses, computerized ventilation systems, and intelligent lighting technologies have significantly enhanced productivity while reducing labour requirements. Such technologies also improve animal welfare by maintaining optimal environmental conditions throughout production cycles.

Blockchain technology is increasingly used to establish transparent and traceable livestock value chains. From farm to consumer, blockchain records every stage of production, processing, transportation, and marketing, thereby enhancing food safety, consumer confidence, and export competitiveness.

Mobile applications and digital advisory platforms have further democratized access to veterinary services, market information, weather forecasts, and farm management tools. These innovations are particularly valuable for smallholder farmers by improving decision-making and reducing information asymmetry.

Precision livestock farming therefore represents one of the most transformative developments in sustainable animal agriculture, enabling greater productivity with lower environmental footprints.

One Health, Biosecurity, and Animal Welfare

The sustainability of animal agriculture depends fundamentally on healthy animals, healthy ecosystems, and healthy communities. The One Health approach recognizes the close interdependence of human, animal, and environmental health and promotes coordinated action across these sectors.

Many emerging infectious diseases affecting humans originate in animals. Consequently, effective disease surveillance, vaccination, biosecurity, and veterinary healthcare not only improve livestock productivity but also protect

public health. Comprehensive biosecurity measures—including controlled farm access, sanitation, quarantine, vaccination, pest control, and responsible waste disposal—are essential for preventing disease outbreaks and minimizing economic losses.

Another major concern is antimicrobial resistance (AMR), which has emerged as a global public health challenge. Sustainable livestock systems emphasize prudent antibiotic use, strengthened vaccination programmes, improved hygiene, and alternatives such as probiotics, phyto-genic feed additives, and immunomodulators. These measures reduce reliance on antibiotics while safeguarding animal and human health.

Animal welfare has become an integral component of sustainable livestock production. Consumers increasingly prefer products derived from systems that ensure humane treatment of animals. Good welfare practices—including adequate nutrition, comfortable housing, disease prevention, freedom from unnecessary stress, and opportunities for natural behaviour—not only satisfy ethical expectations but also improve productivity, reproductive efficiency, and product quality.

The internationally accepted Five Freedoms of Animal Welfare continue to guide welfare-oriented livestock management and are increasingly incorporated into certification programmes and international trade standards.

The integration of One Health principles, robust biosecurity, responsible antimicrobial stewardship, and high animal welfare standards strengthens the long-term sustainability, resilience, and public acceptance of modern animal agriculture.

Economic Contributions and Rural Development

Animal agriculture is one of the most dynamic sectors of the global economy and a critical driver of inclusive rural development. Beyond producing milk, meat, eggs, wool, and other animal products, the livestock sector supports a wide range of allied industries, including feed manufacturing, veterinary pharmaceuticals, biotechnology, breeding services, processing, transportation, cold-chain logistics, retail marketing, and exports. This extensive value chain creates employment opportunities for millions of people and stimulates economic activity

across rural and urban areas.

In India, the livestock sector contributes approximately 30% of Agricultural Gross Value Added (GVA) while accounting for nearly 5% of the national Gross Domestic Product (GDP). The sector has consistently exhibited higher growth rates than the crop sector over the past decade, highlighting its increasing importance in the national economy. Dairy farming remains the largest agricultural enterprise in India, while the poultry industry has emerged as one of the fastest-growing segments due to technological advancements in genetics, nutrition, hatchery management, feed manufacturing, and disease control.

Livestock also functions as an effective instrument for poverty alleviation. For smallholder farmers and landless households, animals serve as productive assets that generate regular income throughout the year. Daily milk sales, periodic egg production, and the marketing of livestock products provide continuous cash flow, enabling families to meet household expenses, invest in education and healthcare, and reduce financial vulnerability.

Women constitute a significant proportion of the livestock workforce, particularly in dairy farming, backyard poultry, goat rearing, and small-ruminant management. Their active participation enhances household nutrition, promotes financial inclusion, strengthens decision-making capacity, and contributes to gender equality. Livestock development programmes focusing on women-led self-help groups, dairy cooperatives, and rural entrepreneurship have demonstrated substantial success in improving livelihoods and fostering inclusive economic growth.

Youth engagement in livestock farming has also increased with the emergence of commercial dairy enterprises, integrated poultry farming, precision livestock technologies, and digital marketing platforms. These developments have created opportunities for agripreneurship and employment, helping to reduce rural unemployment and migration.

Thus, animal agriculture remains a cornerstone of rural prosperity by generating employment, reducing poverty, empowering marginalized communities, and supporting sustainable economic development.

Emerging Challenges and Future Opportunities

Despite its remarkable contributions, animal agriculture faces several interconnected challenges that must be addressed to ensure long-term sustainability.

Climate change remains one of the most pressing concerns. Rising temperatures, altered rainfall patterns, and frequent extreme weather events adversely affect animal health, feed availability, reproductive efficiency, and water resources. Heat stress alone can significantly reduce milk yield, growth rate, egg production, and fertility. Building climate-resilient livestock systems through improved genetics, climate-smart housing, and efficient water management is therefore imperative.

Feed security presents another critical challenge. Escalating prices of conventional feed ingredients such as maize and soybean meal, coupled with increasing competition from biofuel and food industries, have heightened production costs. Future sustainability will depend on developing alternative feed resources, precision nutrition, insect protein, algae-based feeds, and greater utilization of agro-industrial by-products.

Animal health continues to be threatened by emerging and re-emerging diseases, antimicrobial resistance (AMR), and transboundary animal diseases. Strengthening veterinary infrastructure, disease surveillance, molecular diagnostics, vaccination programmes, and antimicrobial stewardship is essential to protect livestock productivity and public health.

At the same time, **consumer expectations** are changing rapidly. Demand for safe, traceable, ethically produced, and environmentally sustainable animal products has increased considerably. This trend creates opportunities for certified production systems, blockchain-based traceability, animal welfare certification, and premium value-added products.

Technological innovation provides unprecedented opportunities for addressing these challenges. Artificial intelligence, precision livestock farming, genomics, gene editing, robotics, remote sensing, and digital advisory platforms are revolutionizing livestock management by improving efficiency, reducing production costs, and enhancing sustainability.

Policy Framework and Strategic Roadmap

The transformation of animal agriculture into a sustainable and resilient sector requires coordinated action among governments, research institutions, industry, farmers, and civil society. A comprehensive policy framework should emphasize productivity enhancement, environmental sustainability, technological innovation, and social inclusion.

The following strategic priorities are essential: Strengthen animal health systems Promote climate-smart livestock production, expand precision livestock farming, develop sustainable feed systems, encourage circular bioeconomy practices, improve animal welfare standards, Support research and innovation, empower farmers through extension education, strengthen livestock value chains, Promote One Health etc. Such policy interventions will create a livestock sector that is economically viable, environmentally responsible, socially inclusive, and resilient to future uncertainties.

Way Forward

Animal agriculture is far more than a source of milk, meat, eggs, and fibre; it is a multidimensional system that underpins food security, nutritional well-being, rural livelihoods, environmental stewardship, and economic development. By converting agricultural residues into high-value foods, recycling nutrients, supporting integrated farming systems, and generating renewable energy, livestock contributes significantly to sustainable resource management and the circular bioeconomy.

The sector is undergoing a profound transformation driven by scientific innovation and digital technologies. Precision livestock farming, artificial intelligence, genomic selection, climate-smart management, renewable energy, and One Health approaches are redefining the future of sustainable livestock production. These advancements enable producers to increase productivity while reducing environmental impacts, improving animal welfare, and enhancing resilience to climate change.

Nevertheless, challenges related to climate variability, feed resource constraints, disease emergence, antimicrobial resistance, and evolving consumer expectations require sustained investment in research, infrastructure, education,

and policy reform. Strengthening veterinary services, promoting responsible resource use, fostering public–private partnerships, and encouraging technology adoption will be critical for ensuring the long-term sustainability of the livestock sector.

For India, where livestock supports millions of rural households and contributes substantially to agricultural growth, sustainable animal agriculture represents both an economic opportunity and a developmental necessity. By integrating science, innovation, and sound governance with traditional knowledge and farmer participation, the country can build resilient livestock systems that contribute to national food security, rural prosperity, and environmental sustainability.

In the context of the United Nations Sustainable Development Goals (SDGs), animal agriculture contributes directly to poverty reduction (SDG 1), zero hunger (SDG 2), good health and well-being (SDG 3), gender equality (SDG 5), decent work and economic growth (SDG 8), responsible consumption and production (SDG 12), climate action (SDG 13), and life on land (SDG 15). Thus, sustainable animal agriculture is not merely a component of agricultural development; it is a strategic pillar for achieving a resilient, equitable, and sustainable future.

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TRANSFORMING LIVESTOCK FARMING BY USING DIGITAL TECHNOLOGIES

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Digitalisation is an integral part of modern agriculture. Several digital technologies are available for different animal species and form the basis for precision livestock farming. Livestock farming has long been a cornerstone of global agriculture, providing meat, milk, eggs, fiber, and other essential products that support food security and rural livelihoods. As the world's population continues to grow and the demand for animal-based products increases, the livestock sector faces significant challenges, including climate change, disease outbreaks, labour shortages, rising production costs, and concerns about environmental sustainability and animal welfare. To address these challenges, digital technologies are transforming traditional livestock farming into a more efficient, productive, and sustainable enterprise. The integration of digital technologies, including the Internet of Things, Artificial Intelligence, precision livestock farming, big data analytics, drones, block chain, robotics, and cloud computing, is revolutionizing animal agriculture. These technologies enable farmers to monitor animal health in real time, optimize feeding strategies, improve breeding efficiency, reduce environmental impacts, and make informed management decisions based on accurate data.

Precision Livestock Farming: Precision livestock farming refers to the application of advanced technologies to monitor individual animals continuously and automatically. Sensors attached to animals or installed within livestock facilities collect real-time information on body temperature, movement, feeding behaviour, water intake, rumination, and milk production. These information enable farmers to identify health problems at an early stage, detect estrus accurately, monitor animal welfare, and improve reproductive performance. Early detection of illness reduces treatment costs, minimizes production losses, and decreases the need

for excessive antibiotic use, thereby supporting sustainable livestock production. PLF also allows individualized animal management, ensuring that each animal receives appropriate nutrition and healthcare according to its specific needs, leading to higher productivity and improved welfare.

Internet of Things in Livestock Farming: It has become one of the most influential technologies in modern livestock production. It consists of interconnected devices such as wearable sensors, GPS collars, smart ear tags, automated feeders, and environmental monitoring systems that communicate through wireless networks. Farmers can remotely monitor animal location, health status, feeding behaviour, and environmental conditions using smart phones or computers. Smart sensors continuously measure barn temperature, humidity, ventilation, and air quality, ensuring optimal living conditions for livestock. Internet of things based monitoring systems generate alerts whenever abnormal behaviour or health indicators are detected, allowing immediate intervention before diseases spread or productivity declines.

Artificial Intelligence and Machine Learning: Artificial Intelligence and Machine Learning are enhancing livestock management by analyzing large volumes of farm data and identifying patterns that humans may overlook. AI-powered software can predict disease outbreaks, optimize feeding schedules, estimate growth rates, and improve breeding decisions. Computer vision technologies use cameras to monitor animal behaviour automatically. These systems can detect lameness, stress, aggression, reduced feed intake, and other behavioural changes that may indicate health problems. Machine learning algorithms continuously improve their accuracy as more data become available, enabling increasingly precise recommendations for farm management.

Automated Feeding Systems: Automation has significantly improved feeding efficiency in livestock farms. Smart feeding systems deliver precise quantities of feed according to each animal's nutritional requirements, age, body weight, and production stage. Automated feeding reduces feed wastage, lowers production costs, and improves feed conversion efficiency. Since feed accounts for a major proportion of livestock production expenses, optimizing feeding practices directly improves farm profitability. Some advanced systems continuously monitor feed intake and automatically adjust feed formulations to maximize productivity while minimizing nutrient losses and environmental pollution.

Robotic Milking Systems: The dairy industry has experienced remarkable technological advancement through robotic milking systems. Automatic milking machines allow cows to be milked voluntarily without requiring constant human supervision. Robotic systems identify individual cows using electronic tags, clean the udder, attach milking equipment, monitor milk quality and record milk yield automatically. These systems improve labour efficiency, reduce stress on animals, increase milking frequency, and provide valuable information on udder health, enabling early detection of mastitis and other diseases.

Drones and Remote Sensing: Drones are increasingly used in livestock farming for pasture monitoring, herd surveillance, and infrastructure inspection. Equipped with high-resolution cameras and thermal imaging sensors, drones help farmers monitor grazing animals over large areas quickly and efficiently. Remote sensing technologies assess pasture quality, vegetation growth, soil moisture, and water availability. These data help farmers optimize grazing management, prevent overgrazing, and improve pasture productivity. Drones also assist in locating missing animals, monitoring fencing conditions, and assessing damage following natural disasters.

Big Data and Cloud Computing: Modern livestock farms generate enormous amounts of data from sensors, automated equipment, veterinary records, production databases, and weather stations. Big data analytics transforms these data into actionable information. Cloud computing enables farmers to store, access, and analyze farm

information from any location. Data integration from multiple sources provides comprehensive insights into animal performance, farm efficiency, disease trends, and financial management. Predictive analytics supports decision-making by forecasting production outcomes, identifying risk factors, and recommending preventive measures before problems occur.

Blockchain Technology: Blockchain technology improves transparency and traceability throughout livestock supply chains. Every stage of production from breeding and feeding to veterinary treatment, transportation, processing, and marketing can be securely recorded. Consumers increasingly demand information about food safety, animal welfare, and product origin. Blockchain provides tamper-resistant records that verify production practices and enhance consumer confidence. The technology also supports disease control by enabling rapid tracing of infected animals and contaminated products during disease outbreaks.

Digital Health Monitoring: Wearable devices and smart biosensors continuously monitor physiological parameters such as heart rate, body temperature, respiration rate, rumination, and activity levels. These technologies enable early diagnosis of diseases including mastitis, ketosis, respiratory infections, and metabolic disorders. Early treatment reduces mortality, improves animal welfare, and minimizes economic losses. Digital veterinary platforms further facilitate remote consultations, electronic health records, and timely disease reporting.

Environmental Sustainability: Digital technologies contribute significantly to environmental sustainability by improving resource-use efficiency and reducing greenhouse gas emissions. Precision feeding minimizes methane production by optimizing nutrient utilization. Smart manure management systems monitor waste handling and reduce emissions through improved storage and treatment practices. Environmental sensors optimize water use, ventilation, and energy consumption within livestock facilities, reducing the environmental footprint of animal production. Digital monitoring also supports climate-smart livestock farming by helping producers adapt to changing weather conditions and extreme climatic events.

Challenges to Adoption: Despite their numerous benefits, digital technologies face several barriers to widespread adoption. High initial investment costs, inadequate internet connectivity in rural areas, limited digital literacy among farmers, concerns regarding data privacy, and lack of technical support remains significant challenges. Smallholder farmers, particularly in developing countries, may find advanced technologies financially inaccessible. Government support, affordable financing, training programs, and public-private partnerships are essential for increasing technology adoption. Reliable infrastructure, effective extension services, and farmer education are equally important to maximize the benefits of digital transformation.

Future Prospects: The future of livestock farming will increasingly rely on integrated digital ecosystems where AI, IoT, robotics, Blockchain, and big data work together seamlessly. Emerging technologies such as digital twins, autonomous farm vehicles, genomic data analysis, and advanced biosensors will further enhance productivity, sustainability, and animal welfare. Future smart farms will use predictive analytics to prevent disease outbreaks, optimize resource utilization, improve breeding efficiency, and reduce environmental impacts while maintaining high

production standards. Digital agriculture will also strengthen resilience against climate change, market volatility, and global food security challenges.

Conclusion: Digital technologies are fundamentally transforming livestock farming by making production systems more intelligent, efficient, sustainable, and welfare-oriented. Precision livestock farming, IoT, artificial intelligence, robotics, blockchain, drones, and big data analytics enable real-time monitoring, informed decision-making, improved animal health, and enhanced productivity. Although challenges such as investment costs and technological accessibility remain, continued innovation, supportive policies, and farmer education will accelerate digital adoption across the livestock sector. As agriculture enters the era of smart farming, digital technologies will play a pivotal role in ensuring sustainable livestock production, improving food security, protecting the environment, and meeting the growing global demand for high-quality animal products.

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SUSTAINABLE LIVESTOCK FARMING: EMPOWERING RURAL LIVELIHOODS AND FOOD SECURITY

Jyoti Palod, Sneha Negi and Vidya Sagar Singh

Livestock is a cornerstone of global agriculture, contributing to food production, nutritional security, rural livelihoods, and economic development. It provides meat, milk, eggs, fibre, manure, and draft power while generating income, employment, and resilience for millions of smallholder farmers, particularly in developing countries. Rising population, urbanization, and changing dietary preferences continue to increase the demand for animal-source foods, making livestock an essential component of sustainable food systems. However, livestock production faces major challenges, including climate change, greenhouse gas emissions, land degradation, water scarcity, biodiversity loss, emerging diseases, and inefficient resource use (FAO, 2023a; Gerber *et al.*, 2013; Intergovernmental Panel on Climate Change, 2022). These issues highlight the need for production systems that are environmentally responsible, economically viable, and socially inclusive. The importance of sustainable livestock farming has gained increasing global recognition as countries strive to achieve sustainable agriculture and resilient agrifood systems (United Nations, 2015; FAO, 2023b). International organizations such as the Food and Agriculture Organization (FAO) emphasize that improving livestock productivity while conserving natural resources is essential for meeting the growing demand for animal-source foods while minimizing environmental impacts (FAO, 2021). Consequently, sustainable livestock farming has emerged as a key strategy for balancing food production, environmental conservation, and socio-economic development in both developed and developing countries.

Sustainable livestock farming addresses these challenges by promoting efficient resource use, improved animal health and welfare, climate-smart

practices, responsible waste management, and biodiversity conservation while meeting present needs without compromising the ability of future generations to meet their own needs (High Level Panel of Experts on Food Security and Nutrition, 2016; United Nations Environment Programme, 2021). It is based on three pillars: environmental sustainability, economic sustainability, and social sustainability, which together support resource conservation, farm profitability, food and nutritional security, gender equity, employment, and community well-being (FAO, 2019).

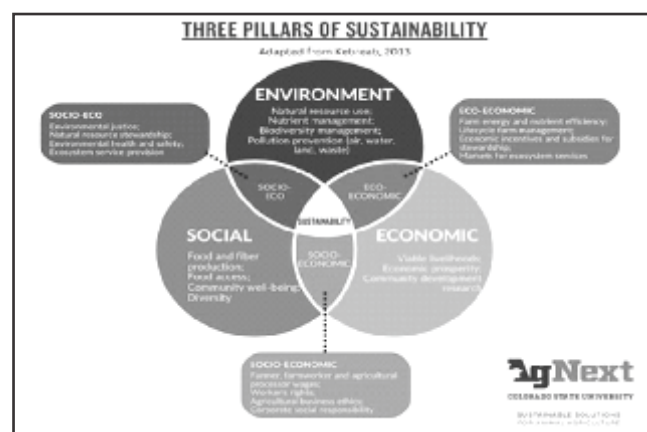


Figure 1. Core pillars of sustainable livestock farming (Colorado State University AgNext)

By balancing these environmental, economic, and social dimensions, sustainable livestock farming strengthens rural livelihoods, enhances food security, supports the Sustainable Development Goals (SDGs), and promotes resilient agricultural systems and sustainable rural development (United Nations, 2015; FAO, 2021).

Livestock for Rural Livelihoods and Food Security

Livestock plays a vital role in sustaining rural livelihoods, particularly in developing countries where it directly supports the livelihoods of

millions of poor smallholder farmers. Beyond providing food, livestock serves as a productive asset that generates regular income, creates employment, and strengthens the resilience of farming communities. Employment opportunities extend across the livestock value chain, including breeding, feeding, animal healthcare, processing, transportation, and marketing. Unlike seasonal crop farming, livestock provides continuous economic returns through the sale of milk, meat, eggs, wool, hides, and other animal products, thereby diversifying household income and reducing vulnerability to market fluctuations and climatic uncertainties (Thornton, 2010; FAO, 2019).

Unlike seasonal crop farming, livestock provides continuous economic returns through the sale of milk, meat, eggs, wool, hides, and other animal products, thereby diversifying household income and reducing vulnerability to market fluctuations and climatic uncertainties (Thornton, 2010; FAO, 2019). It also functions as a valuable financial asset that can be sold during emergencies, crop failures, or economic hardships, contributing to poverty reduction and sustainable rural development.

In addition to supporting livelihoods, livestock is indispensable for achieving food and nutritional security. Animal-source foods such as milk, meat, eggs, and dairy products provide high-quality protein, essential amino acids, vitamins, and minerals that are crucial for healthy growth, cognitive development, immunity, and overall well-being. These nutrient-rich foods are particularly important for children, pregnant and lactating women, and other nutritionally vulnerable groups, helping to reduce protein-energy malnutrition and micronutrient deficiencies (Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme & World Health Organization, 2023c). Sustainable livestock farming contributes to all four dimensions of food security—availability, access, utilization, and stability (High Level Panel of Experts on Food Security and Nutrition, 2016).

It enhances food availability by ensuring a continuous supply of nutrient-rich animal-source foods throughout the year. It improves food access by generating regular income and employment, enabling rural households to purchase diverse and nutritious foods while reducing poverty and

vulnerability. Food utilization is strengthened through the consumption of highly bioavailable nutrients present in milk, meat, and eggs, which are essential for healthy growth, improved immunity, and overall well-being. Livestock also contributes to the stability of food systems by serving as a reliable source of food and income during crop failures, climate-related disasters, market fluctuations, and other economic shocks, thereby increasing household resilience. Furthermore, sustainable livestock systems play an important role in transforming agrifood systems by improving productivity, promoting dietary diversity, and supporting the achievement of Sustainable Development Goal 2 (Zero Hunger), while ensuring that food systems remain inclusive, resilient, and environmentally sustainable (United Nations, 2015; FAO, 2023b).

Livestock further enhances household food security by ensuring a regular supply of nutritious foods throughout the year while generating income to purchase other essential food items. Within integrated crop–livestock systems, animals efficiently convert crop residues and agricultural by-products that are unsuitable for human consumption into valuable food products while supplying manure to maintain soil fertility, thereby improving resource-use efficiency and agricultural sustainability (Shanmugam *et al* 2024; Mottet *et al.*, 2017). Such integrated systems strengthen nutrient recycling, reduce dependence on external inputs, improve soil health, and increase farm resilience against climate variability. Livestock farming also plays an important role in women's empowerment and youth engagement in agriculture. Women actively participate in dairy farming, backyard poultry, goat rearing, feeding, milking, animal care, and the marketing of livestock products, while livestock enterprises provide rural youth with opportunities for entrepreneurship, skill development, and self-employment. Their participation strengthens household decision-making, enhances social inclusion, and contributes to inclusive rural development (Food and Agriculture Organization of the United Nations, 2019). By generating employment, diversifying income, improving nutrition, promoting gender equity, and strengthening the resilience of farming households, sustainable livestock farming contributes significantly to rural prosperity, food and

nutritional security, and the development of resilient and sustainable agricultural systems (Food and Agriculture Organization of the United Nations, 2021).

Sustainable Livestock Farming Practices

Achieving sustainable livestock farming requires the adoption of management practices that enhance productivity while conserving natural resources, improving animal health and welfare, and minimizing environmental impacts. The following practices contribute to efficient resource utilization, climate resilience, and the long-term sustainability of livestock production systems (Food and Agriculture Organization of the United Nations, 2021).

1) Balanced Nutrition and Efficient Feeding

Balanced nutrition is fundamental to sustainable livestock production. Providing animals with nutritionally balanced diets according to their species, age, and physiological status improves growth, reproduction, feed efficiency, and overall health while reducing feed wastage and production costs. Efficient feeding strategies, including precision feeding and the use of locally available feed resources and crop by-products, optimize nutrient utilization and lower methane emissions and nutrient losses to the environment. Improving feed quality is also recognized as one of the most effective strategies for enhancing livestock productivity while reducing the environmental footprint of animal production (Thornton, 2010; Food and Agriculture Organization of the United Nations, 2021).

2) Breed Improvement and Conservation of Indigenous Breeds

Genetic improvement through selective breeding enhances productivity, feed efficiency, disease resistance, and adaptability to changing environmental conditions. At the same time, conserving indigenous livestock breeds is equally important because these breeds possess valuable traits such as heat tolerance, resistance to endemic diseases, and the ability to thrive under low-input production systems. A balanced breeding approach that combines genetic improvement with conservation of indigenous breeds contributes to sustainable and climate-resilient livestock production (Department of Animal Husbandry and

Dairying, 2024e).

3) Disease Prevention and Biosecurity

Maintaining animal health through preventive healthcare is a key component of sustainable livestock farming. Regular vaccination, disease surveillance, biosecurity measures, proper sanitation, and early disease diagnosis reduce disease outbreaks, minimize economic losses, and decrease the indiscriminate use of antimicrobials. Healthy animals are more productive, require fewer therapeutic interventions, and contribute to safer, more efficient, and sustainable livestock production systems (Department of Animal Husbandry and Dairying, 2024b; World Health Organization, 2022).

4) Animal Welfare

Animal welfare is an integral component of sustainable livestock farming, as healthy and stress-free animals are more productive, disease-resistant, and efficient in utilizing feed resources. Good welfare practices include providing adequate nutrition, clean water, comfortable housing, proper ventilation, timely veterinary care, and protection from pain, injury, disease, fear, and distress. Adhering to internationally recognized animal welfare principles not only improves animal health and productivity but also enhances product quality, consumer confidence, and the overall sustainability of livestock production systems (World Organisation for Animal Health, 2023).

5) Efficient Water Management

Water is one of the most critical resources in livestock production. Providing animals with continuous access to clean, safe, and good-quality drinking water is essential for maintaining health, feed intake, growth, reproduction, and milk production. Sustainable water management involves efficient water use, prevention of water contamination, rainwater harvesting where feasible, and proper treatment and reuse of wastewater. These practices help conserve water resources, improve production efficiency, and reduce the environmental impact of livestock farming (Food and Agriculture Organization of the United Nations, 2021).

6) Climate-Smart Housing

Climate-smart housing enhances animal comfort

while minimizing environmental impacts. Well-designed livestock shelters with adequate ventilation, insulation, drainage, and protection from extreme weather conditions help reduce heat stress, improve animal welfare, and maintain productivity. The adoption of energy-efficient housing designs, renewable energy sources, and environmentally friendly waste management systems further strengthens the resilience and sustainability of livestock production under changing climatic conditions (Intergovernmental Panel on Climate Change, 2022; Food and Agriculture Organization of the United Nations, 2021).

7) Sustainable Grazing and Pasture Management

Sustainable grazing practices improve pasture productivity while conserving soil, water, and biodiversity. Controlled or rotational grazing prevents overgrazing, promotes vegetation regeneration, improves soil fertility, and reduces land degradation. Proper pasture management also enhances carbon sequestration, supports ecosystem health, and ensures a sustainable supply of quality forage for livestock (Food and Agriculture Organization of the United Nations, 2023a; United Nations Environment Programme, 2021).

8) Precision Livestock Farming

Precision Livestock Farming (PLF) integrates advanced technologies such as sensors, artificial intelligence (AI), the Internet of Things (IoT), wearable devices, and automated monitoring systems to improve livestock management. These technologies enable real-time monitoring of animal health, behaviour, feed intake, and environmental conditions, allowing early disease detection and timely management interventions. By improving production efficiency, optimizing resource use, reducing labour requirements, and enhancing animal welfare, precision livestock farming is emerging as a key driver of sustainable and climate-resilient livestock production (Berckmans, 2014, 2017).

9) Integrated Crop–Livestock Farming

Integrated Crop–Livestock Farming integrates crop and livestock enterprises as a key principle of sustainable agriculture. Crop residues and agricultural by-products are efficiently utilized as

livestock feed, while animal manure is recycled as organic fertilizer to improve soil fertility and crop productivity. Such integration enhances nutrient recycling, reduces dependence on chemical fertilizers, improves resource-use efficiency, diversifies farm income, and increases resilience to climate variability. By creating a circular production system, integrated farming minimizes waste and contributes to environmentally sustainable and economically viable agriculture (Shanmugam *et al.*, 2024; Mottet *et al.*, 2017).

Collectively, these sustainable livestock farming practices enhance productivity, improve animal health and welfare, conserve natural resources, strengthen climate resilience, and ensure environmentally responsible, economically viable, and socially inclusive livestock production for future generations (Food and Agriculture Organization of the United Nations, 2021).

Livestock Waste Valorization

Livestock farming generates substantial quantities of manure, urine, bedding materials, crop residues, and other organic by-products that, when managed scientifically, can be transformed into valuable resources rather than environmental pollutants. Through sustainable waste management practices such as composting, vermicomposting, and anaerobic digestion, livestock waste can be converted into nutrient-rich organic fertilizers, biofertilizers, renewable biogas, and other value-added products, promoting the principles of a circular bioeconomy while improving resource-use efficiency and farm profitability (Food and Agriculture Organization of the United Nations, 2023a). Composting and vermicomposting stabilize organic matter, reduce pathogens and odours, enhance soil fertility, improve water-holding capacity, and reduce dependence on chemical fertilizers. Similarly, anaerobic digestion converts livestock manure into methane-rich biogas for cooking, heating, and electricity generation, while the nutrient-rich digestate serves as an excellent organic fertilizer, ensuring efficient nutrient recycling and reducing greenhouse gas emissions (United Nations Environment Programme, 2021). Emerging technologies are further expanding the scope of livestock waste utilization through the production of biochar, organic manure pellets, liquid biofertilizers, and other bio-based products that create additional

income opportunities for farmers. Innovative approaches such as the use of black soldier fly larvae for converting organic livestock waste into high-quality insect protein and organic fertilizer are also gaining attention as sustainable waste management solutions. These technologies promote resource recovery, reduce environmental pollution, and support the transition towards a circular and climate-smart bioeconomy. Furthermore, integrating livestock with crop production creates a circular agricultural system in which crop residues are utilized as animal feed and manure is returned to the soil, replenishing essential nutrients and improving soil health. This “Waste to Wealth” approach minimizes waste, conserves natural resources, diversifies farmers' income, and contributes to climate-smart agriculture, sustainable rural livelihoods, and long-term food security (Shanmugam *et al.*, 2024; Food and Agriculture Organization of the United Nations, 2021).

Climate-Smart and Digital Livestock Farming

Climate change is one of the greatest challenges to sustainable livestock production. Rising temperatures, erratic rainfall, prolonged droughts, and the increasing frequency of extreme weather events adversely affect animal health, productivity, reproduction, feed availability, and water resources. At the same time, the livestock sector contributes to climate change through greenhouse gas emissions, particularly methane from enteric fermentation and manure management, making both climate adaptation and mitigation essential for sustainable livestock development (Intergovernmental Panel on Climate Change, 2022; Gerber *et al.*, 2013). Climate-smart livestock farming aims to enhance productivity while reducing environmental impacts and strengthening resilience. Strategies such as improving feed efficiency, adopting climate-resilient production systems, conserving natural resources, improving manure management, and utilizing indigenous livestock breeds help reduce greenhouse gas emissions, optimize resource utilization, and improve resilience to climatic stresses (Food and Agriculture Organization of the United Nations, 2021). Effective heat stress management through proper housing, ventilation, continuous access to clean drinking water, balanced nutrition, and timely health care further helps maintain animal productivity and welfare under changing climatic conditions (Herrero *et al.*, 2021).

Digital technologies are further strengthening climate-smart livestock farming by improving farm management, production efficiency, and environmental sustainability. Precision Livestock Farming (PLF) integrates technologies such as artificial intelligence (AI), the Internet of Things (IoT), sensors, wearable devices, and automated monitoring systems to continuously monitor

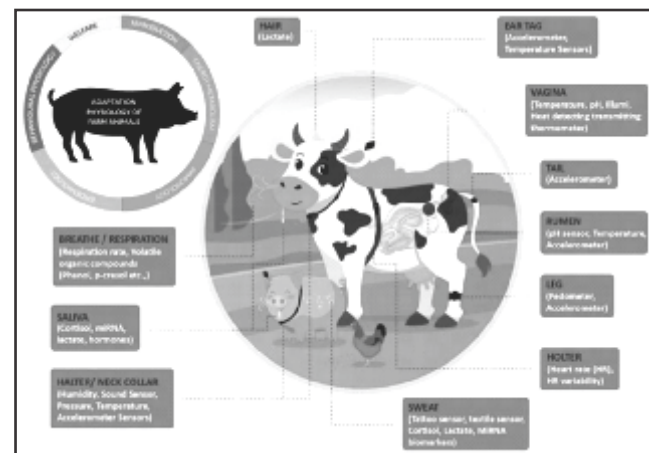


Figure 2. Digital technologies enabling smart and sustainable livestock farming. (Neethirajan, 2020)

animal health, behaviour, production performance, feed intake, water consumption, and environmental conditions. Real-time monitoring enables early disease detection, timely management interventions, and evidence-based decision-making, thereby improving animal welfare and reducing production losses (Berckmans, 2014, 2017). In addition, digital advisory platforms and decision-support tools provide farmers with timely information on disease outbreaks, weather conditions, market trends, and best management practices. Emerging digital innovations such as blockchain technology, Geographic Information Systems (GIS), remote sensing, drones, and mobile-based advisory applications are further expanding the scope of climate-smart livestock farming.

These technologies improve animal traceability, disease surveillance, precision pasture management, and supply chain transparency while enabling farmers to access real-time weather forecasts, market information, and expert advisory services. Such digital solutions strengthen evidence-based decision-making, improve food

safety and consumer confidence, and enhance the overall sustainability, resilience, and efficiency of livestock production systems (Department of Animal Husbandry and Dairying, 2024c). By optimizing resource utilization, reducing waste, improving energy and water efficiency, and supporting climate-smart management, digital technologies are emerging as powerful tools for building resilient, productive, and sustainable livestock production systems (Food and Agriculture Organization of the United Nations, 2021; Herrero *et al.*, 2021).

Challenges and Future Directions in Sustainable Livestock Farming

Despite its critical role in strengthening rural livelihoods, food security, and economic development, sustainable livestock farming faces numerous environmental, economic, technological, and social challenges that limit its widespread adoption. In many developing countries, livestock production is dominated by smallholder farmers who often operate on fragmented landholdings with limited access to quality feed, improved breeding stock, veterinary services, institutional credit, modern technologies, and organized markets. These constraints reduce productivity, limit profitability, and hinder the transition towards climate-smart and sustainable livestock production systems (Food and Agriculture Organization of the United Nations, 2024b). Environmental concerns such as greenhouse gas emissions, land degradation, biodiversity loss, water scarcity, and inefficient livestock waste management further threaten the long-term sustainability of the sector. Animal health and welfare issues, including emerging and re-emerging diseases, inadequate biosecurity, antimicrobial resistance, poor housing, and nutritional deficiencies, continue to affect livestock productivity and farm profitability. Climate change, rising production costs, inadequate infrastructure, weak extension services, and limited awareness among farmers further constrain the widespread adoption of sustainable livestock farming.

Addressing these challenges requires a forward-looking approach that integrates technological innovation, efficient resource management, climate resilience, and supportive policies. Future progress in sustainable livestock farming will depend on strengthening research and innovation, accelerating

the adoption of affordable and accessible technologies, and enhancing collaboration among research institutions, extension agencies, policymakers, private industries, and farming

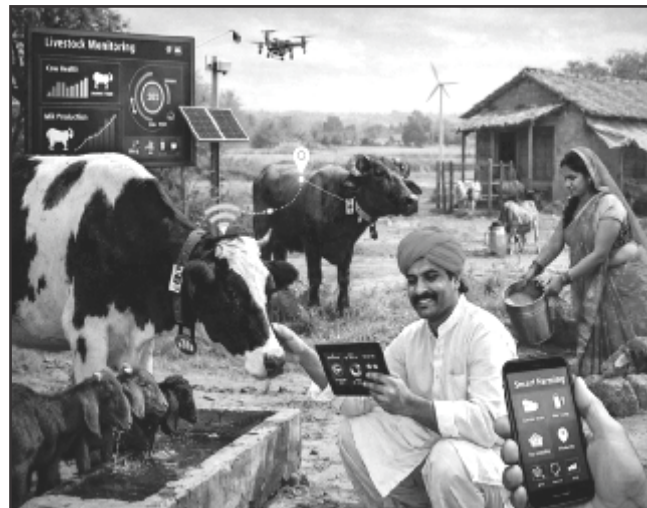


Figure 3. Future pathways for sustainable livestock farming (TGT Global Development Services Limited)

communities to ensure the effective transfer of knowledge and technologies to smallholder farmers. Likewise, adopting a circular bioeconomy by converting livestock waste into biogas, biofertilizers, and other value-added products can improve nutrient recycling, strengthen crop–livestock integration, and enhance resource-use efficiency. Future livestock systems should also emphasize climate-smart breeding, efficient feed and water management, and the adoption of silvopastoral and agroecological production systems to improve resilience, enhance carbon sequestration, and reduce greenhouse gas emissions. Furthermore, the One Health and One Welfare approaches highlight the interconnectedness of animal, human, and environmental health by promoting improved biosecurity, responsible antimicrobial use, and better animal welfare practices (World Health Organization, 2022; World Organisation for Animal Health, 2023).

Strengthening livestock value chains through improved market linkages, Farmer Producer Organizations (FPOs), producer cooperatives, livestock insurance, value addition, and affordable institutional credit can further improve the economic sustainability and resilience of livestock farming. Achieving these goals will require

sustained investment in research, innovation, extension services, farmer training, digital literacy, stronger public–private partnerships, and inclusive policies that empower smallholder farmers (Department of Animal Husbandry and Dairying, 2024a; Department of Animal Husbandry and Dairying, 2024d; National Dairy Development Board, 2023). Collectively, these measures can build a resilient, resource-efficient, and sustainable livestock sector capable of improving rural livelihoods, strengthening food and nutritional security, and contributing to the achievement of the Sustainable Development Goals (SDGs) (United Nations, 2015).

Government Initiatives Promoting Sustainable Livestock Farming

The Government of India has launched several flagship programmes to promote sustainable livestock farming by improving animal productivity, conserving indigenous breeds, strengthening animal health services, enhancing feed and fodder availability, encouraging entrepreneurship, and improving the livelihoods of livestock farmers. These initiatives support scientific livestock management, climate-resilient production systems, and efficient resource utilization, thereby contributing to rural development, food security, and sustainable agricultural growth (Department of Animal Husbandry and Dairying, 2024a).

Rashtriya Gokul Mission (RGM): The Rashtriya Gokul Mission is one of the major initiatives aimed at the conservation, development, and genetic improvement of indigenous bovine breeds. The mission promotes advanced breeding technologies such as artificial insemination, sex-sorted semen, in vitro fertilization (IVF), genomic selection, and the National Milk Recording Programme to improve the productivity of cattle and buffaloes. It also supports the strengthening of semen stations, establishment of heifer rearing centres, induction of Multi-purpose AI Technicians in Rural India (MAITRIs), and extensive farmer awareness programmes. By enhancing the productivity of indigenous breeds, particularly those owned by small and marginal farmers, the mission improves milk production, increases farmers' income, conserves valuable indigenous germplasm, and supports sustainable dairy development

(Department of Animal Husbandry and Dairying, 2024e).

National Livestock Mission (NLM): The National Livestock Mission aims to promote entrepreneurship, employment generation, breed improvement, feed and fodder development, livestock insurance, research, innovation, and extension services across multiple livestock sectors, including poultry, sheep, goats, pigs, camels, horses, and donkeys. The mission encourages scientific livestock management through improved breeding, quality feed and fodder production, skill development, and technology dissemination. It also supports fodder processing infrastructure, capacity building, and applied research to improve livestock productivity while reducing production costs. These interventions create employment opportunities, strengthen rural enterprises, and promote climate-resilient livestock production systems (Department of Animal Husbandry and Dairying, 2024d).

National Animal Disease Control Programme (NADCP): Animal health is fundamental to sustainable livestock farming. The National Animal Disease Control Programme focuses on the nationwide control and progressive eradication of Foot and Mouth Disease (FMD) and Brucellosis through systematic vaccination, surveillance, and disease monitoring. Effective disease control reduces mortality, improves reproductive performance and productivity, minimizes economic losses, and ensures the production of safe and quality livestock products (Department of Animal Husbandry and Dairying, 2024a).

Livestock Health and Disease Control (LH&DC) Programme: Complementing the National Animal Disease Control Programme (NADCP), the Livestock Health and Disease Control (LH&DC) Programme adopts a broader approach to strengthening veterinary healthcare by supporting diagnostic laboratories, mobile veterinary units, veterinary infrastructure, disease surveillance, and preventive animal healthcare services. The programme also focuses on improving access to quality veterinary care, enhancing disease diagnosis and control, and strengthening emergency response systems. These interventions improve animal health and welfare, reduce disease-related economic losses, and enhance the resilience and productivity of livestock

production systems (Department of Animal Husbandry and Dairying, 2024b).

National Digital Livestock Mission (NDLM – Bharat Pashudhan): Digital technologies are increasingly transforming livestock management in India. The National Digital Livestock Mission promotes animal identification, traceability, digital health records, and efficient delivery of breeding and veterinary services. These digital interventions improve transparency, disease surveillance, monitoring, and informed decision-making while facilitating better implementation of livestock development programmes (Department of Animal Husbandry and Dairying, 2024c).

Animal Husbandry Infrastructure Development Fund (AHIDF): The Animal Husbandry Infrastructure Development Fund aims to strengthen private investment in dairy processing, meat processing, animal feed plants, breed improvement technologies, and value addition infrastructure. By promoting modern processing facilities, cold-chain infrastructure, and entrepreneurship, the scheme enhances the efficiency and competitiveness of the livestock sector. It also generates rural employment, reduces post-harvest losses, improves farmers' incomes, and supports sustainable livestock value chains (Department of Animal Husbandry and Dairying, 2024a; National Dairy Development Board, 2023).

Collectively, these government initiatives provide a comprehensive framework for sustainable livestock development by integrating scientific breeding, disease prevention, feed and fodder security, digital technologies, entrepreneurship, research, and capacity building. Together, they enhance livestock productivity, conserve indigenous genetic resources, improve animal health and welfare, strengthen rural livelihoods, create employment

opportunities, and contribute significantly to food and nutritional security. By promoting resilient, climate-smart, and inclusive livestock production systems, these programmes are playing a pivotal role in ensuring the long-term sustainability and competitiveness of India's livestock sector (Department of Animal Husbandry and Dairying, 2024a).

Conclusion

Sustainable livestock farming represents the future of resilient, inclusive, and climate-smart agriculture. It goes beyond increasing livestock production by integrating scientific management, efficient resource utilization, improved animal health and welfare, climate-resilient practices, digital innovations, and circular bioeconomy principles to ensure long-term environmental, economic, and social sustainability. As highlighted throughout this article, sustainable livestock systems strengthen rural livelihoods by generating employment, enhancing farm incomes, improving food and nutritional security, empowering women and youth, and promoting efficient crop–livestock integration. Government initiatives, technological advancements, and farmer-centric policies are further accelerating the transition towards sustainable livestock development in India. However, achieving this vision requires the collective efforts of farmers, researchers, policymakers, industry, and consumers to adopt innovative, responsible, and climate-resilient practices. By embracing sustainability today, the livestock sector can become a powerful catalyst for food security, environmental conservation, rural prosperity, and the achievement of the Sustainable Development Goals, ensuring a healthier planet and a more secure future for generations to come.



ARTIFICIAL INTELLIGENCE: TRANSFORMING THE FUTURE OF ANIMAL FEEDING

Brishketu Kumar*, T. K. S. Rao, Dinesh Kumar, and P. D. Akbari

Artificial Intelligence (AI) is emerging as a transformative technology in modern livestock production, particularly in the field of animal feeding and nutrition. Traditionally, feeding decisions have been based on general recommendations according to species, age, body weight, production stage and physiological status. However, individual animals differ considerably in their nutrient requirements, feed intake, production potential and ability to utilise nutrients. AI can integrate large volumes of information and convert it into practical feeding decisions, thereby supporting precision feeding, improved feed efficiency, lower feeding costs and sustainable livestock production.

AI and Precision Animal Feeding

Precision feeding aims to provide each animal with the right amount of nutrients at the right time according to its actual requirements. AI makes this approach more effective by analysing data from multiple sources, including body weight, milk yield, milk composition, feed intake, rumination, activity, environmental conditions and physiological status.

Machine-learning algorithms can identify relationships between these variables and predict nutrient requirements. For example, in dairy cattle, an AI-based system can analyse individual milk production, body weight, lactation stage and previous feed intake and recommend an appropriate ration. This is more precise than providing the same ration to every animal in a herd.

Prediction of Feed Intake

Feed intake is one of the most important determinants of livestock productivity. Conventional measurement of individual feed intake is often difficult, particularly in large commercial farms. AI combined with sensors,

cameras and automated feeding equipment can estimate individual feed intake and feeding behaviour.

Computer-vision systems can monitor the time an animal spends at the feed bunk, frequency of feeding visits and quantity of feed consumed. These data can be analysed using machine-learning models to identify changes in feeding behaviour. A sudden reduction in feed intake may indicate illness, heat stress, metabolic problems or poor feed quality, allowing early intervention.

AI-Based Ration Formulation

Ration formulation requires balancing energy, protein, fibre, minerals, vitamins and other nutrients according to animal requirements. AI can improve this process by simultaneously considering nutritional requirements, feed composition, feed availability and feed cost.

An AI-based ration formulation system can select combinations of locally available feed ingredients while satisfying nutrient requirements at minimum cost. This can be particularly useful when prices of maize, soybean meal, oil cakes, wheat bran and other feed ingredients fluctuate.

AI can therefore help farmers formulate least-cost and nutrient-balanced rations while reducing unnecessary nutrient supplementation.

Improving Feed Efficiency

Feed is one of the largest variable costs in livestock production. Therefore, improving feed efficiency is essential for profitable animal production. AI can analyse the relationship between feed intake and production performance to identify animals that efficiently convert feed nutrients into milk, meat or eggs.

In dairy cattle and buffaloes, AI can analyse dry matter intake, milk yield, milk composition and body-weight changes to estimate feed efficiency. Animals with superior feed efficiency can potentially be identified for breeding programmes, while feeding strategies can be adjusted for less efficient animals.

Monitoring Rumen Function and Ruminant Nutrition

In ruminants, proper rumen fermentation is essential for efficient utilisation of fibrous feeds. AI can assist in interpreting data related to rumination time, eating behaviour, feed intake, milk production and metabolic indicators.

Changes in rumination behaviour can provide early indications of inadequate dietary fibre, digestive disturbances or health problems. By combining rumination data with feed and production information, AI systems can assist nutritionists in adjusting rations before serious production losses occur.

AI may also contribute to predicting rumen fermentation characteristics and nutrient utilisation when integrated with laboratory and farm-level datasets.

AI in Dairy Cow Feeding

Dairy animals have rapidly changing nutrient requirements throughout lactation. During early lactation, high-producing cows require diets with high nutrient density, whereas nutritional requirements decline as lactation progresses.

AI-based feeding systems can continuously monitor individual animals and modify feed allocation accordingly. Robotic feeding systems can deliver different quantities or mixtures of feed to individual animals based on their production level and nutritional requirements.

Such systems have the potential to reduce feed wastage while ensuring that high-producing animals receive adequate nutrients.

AI in Poultry Feeding

Poultry production also offers significant opportunities for AI-based feeding. Cameras and sensors can monitor flock behaviour, body weight, feed consumption and environmental conditions.

AI algorithms can identify changes in feeding patterns that may indicate disease, heat stress or environmental problems. Automated feeders can then adjust feed delivery according to flock requirements.

In precision poultry production, AI can help optimise the relationship between feed intake, body-weight gain, egg production and feed conversion ratio (FCR).

AI and Feed Quality Assessment

Feed quality has a major influence on animal performance. AI-based image analysis can potentially assist in identifying physical abnormalities in feed ingredients, while predictive models can analyse laboratory data relating to moisture, crude protein, fibre and other nutritional characteristics.

AI can also support prediction of feed quality deterioration during storage by integrating information such as temperature, humidity and storage duration. Early identification of potential feed-quality problems can help prevent reduced animal performance and health complications.

Reducing Feed Waste

Feed wastage increases production costs and contributes to environmental pollution. AI-enabled automated feeding systems can monitor feed availability and animal consumption and adjust feed delivery accordingly.

For example, if a feeding system detects that considerable feed remains uneaten, the quantity delivered during the next feeding period can be adjusted. This can reduce unnecessary wastage and improve feed utilisation.

AI, Sustainability and Environmental Benefits

Efficient feeding is closely linked with sustainable livestock production. When animals use nutrients more efficiently, less feed is required per unit of milk, meat or eggs produced. Better precision in protein and mineral supply can also reduce unnecessary nutrient excretion.

AI can therefore contribute indirectly to reducing the environmental footprint of livestock production by improving feed efficiency, reducing wastage and optimising nutrient utilisation.

Challenges and Future Prospects

Despite its considerable potential, AI-based animal feeding faces several challenges. These include the high initial cost of sensors and automated equipment, lack of reliable farm-level data, technical expertise requirements, internet connectivity problems and difficulties in integrating data from different systems. AI models must also be validated under different breeds, production systems, climates and feeding conditions.

In the future, integration of AI, Internet of Things (IoT), sensors, robotics, genomics, automated feeders and precision livestock farming is likely to create increasingly sophisticated feeding systems. Such systems may continuously monitor an animal's nutritional status and automatically adjust its ration according to real-time requirements.

Conclusion

Artificial Intelligence has the potential to

revolutionise animal feeding by moving livestock nutrition from group-based feeding towards individualised precision nutrition. AI can assist in predicting feed intake, formulating economical rations, improving feed efficiency, detecting changes in feeding behaviour, reducing feed wastage and supporting sustainable livestock production. Its greatest value will come from combining advanced technology with the knowledge of animal nutritionists, veterinarians and farmers. Thus, AI should be viewed not as a replacement for professional expertise, but as a powerful decision-support tool for achieving efficient, economical and sustainable animal feeding.

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BALANCED FEEDING: A SUSTAINABLE PATHWAY TO IMPROVING DAIRY ANIMAL PRODUCTIVITY IN DEVELOPING COUNTRIES

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Executive Summary

Dairy farming is a major source of nutrition, income, employment and livelihood in developing countries, yet milk productivity remains considerably below genetic potential due to inadequate and imbalanced feeding. Feed alone accounts for nearly 70% of the total cost of milk production, making nutritional management the single most influential factor affecting profitability. Balanced feeding—supplying nutrients according to an animal's physiological requirements using available feed resources—offers an economical and climate-smart solution for improving milk yield, reproductive efficiency, animal health, and farm income. Studies conducted under India's ration balancing initiatives have consistently demonstrated improvements in milk production, feed efficiency, reproductive performance and reductions in enteric methane emissions per unit of milk produced.

This review highlights the importance of balanced feeding, the nutritional challenges faced by dairy farmers in developing countries, recent advances in precision nutrition, and practical strategies for sustainable dairy production.

Introduction

The dairy sector plays a vital role in ensuring food security and supporting rural livelihoods across Asia & other developing countries. Countries such as India have become global leaders in milk production; however, average productivity per animal remains substantially lower than in developed dairy-producing nations. One of the principal reasons is poor nutritional management.

Most dairy animals in developing countries depend on crop residues, limited or no natural grazing, and locally available agro-industrial by-products. While

these resources are valuable, they often fail to meet the requirements for energy, protein, minerals, and vitamins needed by elite and high producing dairy animals. As a result, many animals produce only 40–60% of their genetic potential. Balanced feeding has therefore emerged as one of the most practical interventions for increasing productivity while reducing production costs and environmental impacts.

What is Balanced Feeding?

Balanced feeding refers to supplying all essential nutrients in appropriate quantities and proportions to meet the animal's maintenance, growth, pregnancy, and milk production requirements. Ration of milch animals in India usually comprises one or two locally available concentrate feed ingredients, supplemented with green fodder/grasses and crop residues. This often leads to imbalanced feeding which means critical nutrients like protein, energy, minerals and vitamins are either excess or deficient as compared to nutrient requirements. While imbalanced feeding adversely affects the health, productivity and welfare of animals in various ways, it also reduces the net daily income of milk producers as the milk production potential of animals is not fully exploited. Livestock fed imbalanced rations produce more methane, as most of the dietary organic matter is fermented to produce acetate and butyrate, resulting into more methane production. On the contrary, field study has reported that if the ration is balanced for all essential nutrients, organic matter is fermented to produce more microbial biomass and less of methane. Many researchers suggested that the balanced feeding is one of the attractive options for improving livestock productivity with judicious use of available feed resources in developing countries. Scientists also reported that the most relevant CH₄ mitigation

strategy for smallholder dairy production system in developing countries is to increase individual animal productivity as a consequence of providing nutritionally balanced feeds.

A balanced ration should provide:

- Adequate metabolizable energy
- Optimum crude and digestible protein
- Effective fibre for healthy rumen function
- Essential macro- and micro-minerals
- Vitamins A, D and E
- Unlimited clean drinking water

Nutrient requirements vary depending on body weight, breed, stage of lactation, milk yield, reproductive status, climatic conditions, and management practices. Feeding according to these requirements maximizes nutrient utilization while minimizing waste.

Challenges in Developing Countries

Despite advances in dairy genetics and veterinary care, nutrition continues to be the weakest component of dairy production systems.

Major constraints include:

- Shortage of quality green fodder.
- Heavy dependence on low-quality crop residues.
- Seasonal fluctuations in feed availability.
- Inadequate protein supplementation.
- Deficiency of calcium, phosphorus, zinc, copper and other trace minerals.
- High cost of concentrate ingredients.
- Limited farmer awareness regarding scientific feeding.

Many farmers continue to formulate rations based on availability rather than nutrient requirements, leading to either overfeeding of costly concentrates or deficiencies that reduce productivity.

Benefits of Balanced Feeding

• Higher Milk Production

Balanced nutrition improves rumen microbial activity, increases digestibility, and enhances

nutrient availability for milk synthesis. Field studies under ration balancing programs have reported milk yield increases of approximately 2–14%, together with modest improvements in milk fat percentage.

• Improved Feed Efficiency

Scientific ration formulation allows animals to obtain more milk from the same quantity of feed by improving nutrient utilization and reducing wastage.

• Better Reproductive Performance

Balanced mineral and energy nutrition helps reduce delayed puberty, silent heat, repeat breeding, retained placenta, and extended calving intervals.

• Enhanced Animal Health

Adequate nutrition strengthens immunity and lowers the incidence of metabolic disorders such as milk fever, ketosis, ruminal acidosis, and fatty liver. Proper vitamins and trace mineral supplementation also contribute to healthier udders and reduced mastitis risk.

• Increased Farm Profitability

Higher milk yield, improved fertility, lower veterinary costs, and better feed conversion collectively increase net returns. The use of least-cost balanced rations can further reduce feeding expenses without compromising production.

Balanced Feeding and Environmental Sustainability

Sustainable dairy production requires maximizing productivity while minimizing environmental impact.

Balanced feeding contributes to sustainability by:

- Reducing methane emissions per kilogram of milk.
- Improving nitrogen utilization and lowering ammonia losses.
- Reducing phosphorus excretion.
- Enhancing lifetime productivity of dairy animals.

- Lowering the carbon footprint of milk production.

Because maintenance requirements remain relatively constant, increasing milk yield through improved nutrition reduces greenhouse gas emissions per litre of milk. This makes balanced feeding one of the most practical climate-smart interventions for smallholder dairy systems.

Impact of balanced feeding on productivity and productive life

Productive life measures how long dairy animals survive in a herd after they calve for the first time. Milk production of a dairy animal throughout its productive life is largely dependent on age at first calving (AFC), the shape of lactation curve i.e., peak yield and lactation persistency, lactation length, dry period and number of lactations. Average AFC of dairy animals is about 42-48 months and lactation period of 7-9 months with a subsequent dry period of 4-6 months. A dairy animal generally experiences six lactations throughout its productive life, out of a total average life span of 12 years.

Ration with adequate nutrients helps dairy animals to achieve maximum performance, improves the milk production profile throughout its productive life. Feeding ration all essential nutrients can contribute to reduce the AFC from 48 months to 36 months, extended lactation length from 9 months to 10 months, reduced dry period by 3 months and increased number of lactations from six to eight on an average as compared to those animals fed unbalanced ration. Thus, the productive life of a dairy animal can be increased from 54 to 80 months out of a total average life span of 12 years and about 4,500 kg of extra milk production can be achieved in terms of extended lactation length and lactation number and reduced age of first calving and dry period.

Technologies Supporting Balanced Feeding

Recent advances have made scientific feeding more accessible to farmers:

- **Area-Specific Mineral Mixtures:** Correct regional mineral deficiencies and improve reproductive efficiency.
- **Bypass Protein and Bypass Fat Supplements:** Enhance milk production, particularly in high-yielding animals during early lactation.

- **Silage Making:** Preserves nutritious fodder for use during lean seasons and reduces dependence on seasonal green forage.
- **Feed Testing and Quality Assurance:** Laboratory analysis enables accurate nutrient evaluation and formulation of balanced rations.
- **Precision Feeding:** Digital ration-balancing software, mobile advisory platforms, milk recording systems, and sensor-based technologies allow nutrient supply to be matched more closely with animal requirements, improving both productivity and sustainability.
- **Total Mixed Ration (TMR):** Ensures uniform nutrient intake, minimizes feed sorting, and improves rumen fermentation.

Role of the Feed Industry

The compound feed industry has a pivotal role in promoting balanced feeding. Manufacturers can contribute by:

- Producing scientifically formulated compound cattle feeds.
- Ensuring strict quality control of feed ingredients.
- Developing region-specific mineral mixtures.
- Promoting least-cost balanced feed formulations.
- Supporting laboratory-based nutrient evaluation.
- Training farmers through extension programs.
- Collaborating with dairy cooperatives and research institutions.

Organizations such as CLFMA have been instrumental in promoting quality standards, scientific manufacturing practices, and awareness regarding balanced nutrition in livestock production.

Future Directions

Future dairy nutrition should focus on:

- Precision nutrition using digital

technologies.

- Greater utilization of locally available unconventional feed resources.
- Improved fodder production and conservation.
- Methane-reducing feed additives.
- Circular use of agro-industrial by-products.
- Artificial intelligence-assisted ration formulation.
- Strengthening feed analytical laboratories.
- Farmer education through digital advisory platforms.

These innovations will improve efficiency while reducing production costs and environmental impacts.

Conclusion

Balanced feeding remains the cornerstone of

profitable and sustainable dairy production in developing countries. Scientific nutrition enables animals to express their genetic potential, improves milk yield and reproductive performance, strengthens health, and increases farm profitability. At the same time, it contributes to climate-smart livestock production by improving feed efficiency and reducing greenhouse gas emissions per unit of milk.

As demand for milk continues to rise, widespread adoption of balanced feeding practices—supported by quality compound feeds, feed testing laboratories, precision nutrition technologies, and effective extension services—will be essential for achieving sustainable growth in the dairy sector. Investment in balanced feeding is therefore not merely a nutritional intervention but a strategic pathway toward food security, environmental sustainability, and improved livelihoods for millions of dairy farmers.



MICROBIAL FERMENTATION OF FISH FEED: A SUSTAINABLE INNOVATION AT THE HEART OF ANIMAL AGRICULTURE

Chadan Debnath, S. Gojendro Singh, Sandip Ghatak and G. Kadirvel

India's journey as an aquaculture powerhouse is one of the most compelling stories in modern animal agriculture. From producing 95.79 lakh tonnes of fish in 2013-14, the nation has more than doubled its output to 197.75 lakh tonnes in 2024-25, a remarkable 106% growth in just one decade. According to the FAO's State of World Fisheries and Aquaculture (SOFIA) 2026 report, India currently ranks as the 2nd largest producer of aquatic animals in the world, contributing approximately 9% of global aquatic animal production, while the fisheries sector supports the livelihoods of nearly 3 crore fishers and fish farmers across the country. The fisheries sector's GVA reached Rs. 3,68,124 crore in 2023-24, contributing 7.55% to the Agriculture GVA, the highest among all agriculture and allied sectors. The India aquaculture feed market, valued at USD 3.25 billion in 2025, is projected to reach USD 4.84 billion by 2031, growing at a compound annual rate of 6.83%. These numbers are not merely statistics; they reflect the irreplaceable role of aquaculture within the broader canvas of Indian animal agriculture and its direct contribution to national food security, rural employment and sustainable economic growth.

Yet beneath this impressive growth lies a persistent and deepening challenge: the rising cost and dwindling availability of conventional fish feed ingredients, particularly fish meal. Fishmeal prices fluctuated between USD 1,200 and 1,500/ MT in 2024, with quarterly variations of 15 to 20%, making it increasingly unaffordable for small and marginal fish farmers who constitute the backbone of India's inland aquaculture sector. India's domestic fishmeal production has stagnated at 200,000 to 250,000 metric tonnes annually, while aquaculture output has grown at 7 to 9% per year, creating a widening supply-demand gap. Plant-based feed

ingredient costs have risen 18 to 25% over 2021 to 2025, driven by competing demand from the poultry and livestock sectors. Feed cost volatility is now the single largest constraint for India's aquaculture sector. Unless resolved, it threatens to erode the gains of decades of investment and policy support, particularly under flagship programmes like the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY), which has transformed India's fisheries landscape with cumulative approved investments of Rs. 38,572 crore since 2015.

It is in this context that microbial fermentation of fish feed ingredients emerges not merely as a scientific novelty but as a strategically important, transformative and immediately deployable technology. Fermentation, one of the oldest biological processes known to humankind, offers a compelling solution to the twin challenges of feed cost and antinutritional burden of plant-based ingredients. When agricultural by-products such as rice bran, mustard oil cake, soybean meal and groundnut oil cake, which are abundantly available across India, are subjected to microbial fermentation using lactic acid bacteria (LAB) and yeast, the resulting products demonstrate substantially improved protein content, enhanced digestibility and a significant reduction in antinutritional factors that would otherwise limit their safe use in fish diets.

The science behind this transformation is elegant in its simplicity. Lactic acid bacteria, present in abundant quantities in traditional Indian yogurt or dahi, ferment available carbohydrates to produce lactic acid, which rapidly lowers the pH of the fermenting substrate to 4.0-4.5. This acidic environment suppresses harmful bacteria, prevents putrefaction and simultaneously creates conditions in which microbial enzymes, including phytase,

protease and amylase, break down complex antinutritional compounds. Phytic acid, which chelates essential minerals like calcium, zinc and iron and reduces their bioavailability, can be reduced by 50-60% through combined yogurt and yeast fermentation. Tannins, which inhibit digestive enzymes, decline by 40-55%. Glucosinolates in mustard oil cake, the single most restrictive antinutritional factor that limits its dietary inclusion to less than 10% in carp diets in raw form, can be reduced by as much as 70-76% after fermentation, raising the safe inclusion level to 30-40% of the total diet. Crude protein content increases by 15-25% through microbial biomass accumulation and the relative concentration of protein as fermentable carbohydrates are utilised. *In vitro* protein digestibility improves by 15-30 % compared to unfermented substrates.

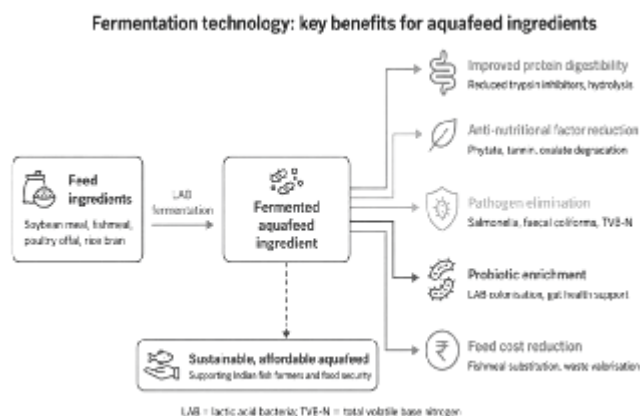


Fig 1: Conceptual diagram showing how fermentation technology connects to five key outcomes, improved protein digestibility, anti-nutritional factor reduction, pathogen elimination, probiotic enrichment, and feed cost reduction, all converging toward sustainable and affordable aquafeed for Indian fish farmers.

What makes this technology particularly compelling for animal agriculture in India is its extraordinary accessibility. Fermentation does not require sophisticated equipment, imported reagents or expensive starter cultures. A modest investment in food-grade containers with simple inlet and outlet modifications to maintain near-anaerobic conditions is sufficient for a fully functional on-farm fermentation unit. Fresh yogurt, available in every rural household and market across the

country, provides a rich and viable source of LAB at a fraction of the cost of commercial microbial inoculants. Baker's yeast, sold widely at low cost in Indian towns, adds complementary enzymatic activity that enhances both carbohydrate breakdown and phytate degradation. Together, these two inoculants, when combined with molasses as a carbon source for microbial growth, produce a synergistic fermentation effect that consistently outperforms either inoculant used alone. The entire fermentation process requires 5-7 days at ambient temperature, making it perfectly suited to the operational rhythms of small and marginal fish farmers in states like West Bengal, Andhra Pradesh, Odisha, Bihar and the North Eastern Region, where the demand for cost-effective feed solutions is most acute.

The implications of this technology for animal agriculture extend well beyond the immediate reduction in feed costs. From an environmental sustainability standpoint, fermentation enables the productive utilisation of agro-industrial by-products that would otherwise be either discarded or sold at low value, transforming them into high-quality feed ingredients. This directly supports the principles of circular economy and zero-waste animal agriculture, which are increasingly central to India's sustainable development agenda. In NE India, where rice cultivation and mustard farming are predominant, rice bran and mustard oil cake are generated in large quantities and are readily available at low cost throughout the year. Fermentation converts these locally available, low-value residues into feed ingredients that can replace a significant proportion of expensive imported fish meal, reducing both the cost of production and the carbon footprint of aquafeed manufacture.

The technology also opens new avenues for the utilisation of animal processing by-products. Poultry and duck offal, generated in substantial quantities by the rapidly growing poultry sector, can be subjected to lactic acid fermentation to produce a safe, nutritious and affordable protein ingredient for fish diets. Fermentation eliminates pathogenic bacteria including Salmonella and faecal coliforms, improves protein availability and reduces total volatile base nitrogen, converting a waste disposal problem into a valued feed resource. Importantly, rural communities across India, from

the fermented foods of the North East to idli, kanji and gundruk elsewhere, already possess the cultural familiarity with fermentation that makes adoption of this technology a natural and intuitive extension of existing practice rather than an unfamiliar intervention.

For policymakers and industry leaders gathered at this 67th National Symposium, several actionable pathways merit serious consideration. First, fermentation technology should be formally integrated into the extension activities of the National Fisheries Development Board (NFDB) and state fisheries departments, with standardised protocols disseminated to fish farmers through Matsya Seva Kendras and Sagar Mitras already established under PMMSY. Second, the technology deserves inclusion in the curriculum and practical training programmes of fisheries colleges and Krishi Vigyan Kendras, equipping the next generation of fish farmers and aquaculture entrepreneurs with a skill that has immediate and measurable economic benefit. Third, industry stakeholders, particularly feed manufacturers, can explore fermentation as a preprocessing step that reduces their raw material costs and enhances the nutritional profile of plant-based ingredients before pelleting, offering a competitive advantage in a market where feed cost is the primary determinant of profitability. Fourth, research institutions including ICAR, NFDB, CAUs and SAUs should be supported in generating species-specific, region-specific data on the growth performance and health indices of commercially important fish species fed with fermented ingredient-based diets, providing the robust evidence base needed for large-scale adoption.

India's aquaculture sector is at an inflection point. The infrastructure, the policy framework, the market demand and the farmer enthusiasm are all in place. What is needed now is an equally robust ecosystem of affordable, sustainable and locally rooted feed solutions that can sustain this momentum without placing undue strain on marine resources or the wallets of small farmers. Microbial fermentation of fish feed ingredients, rooted in the same microbial traditions that have given us yogurt and fermented foods for millennia, offers precisely that solution. It is low-cost, science-backed, environmentally responsible and immediately deployable at scale across every agro-climatic zone of India.

As India continues on its trajectory of sustained aquaculture growth, driven by policy frameworks such as the *PM Matsya Sampada Yojana* and the draft National Fisheries Policy 2020, and as it seeks to further strengthen the role of animal agriculture as the backbone of sustainable national development in alignment with the Sustainable Development Goals, particularly SDG-2 on zero hunger, SDG 8 on decent work and economic growth, and SDG 14 on life below water, fermentation technology stands ready to serve as one of its most reliable and quietly revolutionary allies. The future of Indian aquaculture does not lie only in bigger farms, better genetics and more sophisticated equipment; it lies equally in the intelligent and sustainable use of what already exists in abundance around us, the microbial richness of our traditional foods and the agricultural wealth of our soils, harnessed through science for the benefit of millions.

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SHORT CHAIN FATTY ACIDS (SCFAS): A PROMISING FUNCTIONAL FEED ADDITIVES TO IMPROVE FISH HEALTH AND GROWTH PERFORMANCE

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Abstract:

Short-chain fatty acids (SCFAs) are natural compounds produced by gut microbes when they ferment plant-based fibers in fish diets. These powerful molecules, mainly acetate, propionate, and butyrate, enhance digestion, strengthen gut integrity, modulate immunity, and improve growth performance. SCFAs can be produced in the gut from plant-based ingredients, probiotics, prebiotics, or added directly to feeds as synthetic feed additives. SCFAs play vital role in enhancing the growth, support beneficial microbes, immune modulation, and protection against disease. As a sustainable, antibiotic-free compounds SCFAs offer a promising, natural solution to enhance fish health and their performance in aquaculture and supports responsible farming practices.

Introduction:

Fish has become the most in-demand animal protein globally, surpassing even chicken, pork, and beef. To meet this growing need, aquaculture has emerged as a vital solution for meeting the demand of protein. Farmed fish often experience stress, disease, and poor nutrient absorption which can hinder growth and health. For several decades antibiotics were used to manage these issues, but rising concerns over antibiotic resistance and residue accumulation have led to tighter regulations and a push for safer, natural alternatives. One promising solution lies within the fish itself, the gut microbiota. This diverse community of beneficial microbes aids in digestion, counters harmful pathogens, and enhances immune function. SCFAs support immunity, improve digestion, suppress harmful microbes, and promote healthy growth. They can also be supplemented in feed as natural acidifiers like acetic or butyric acid to amplify their benefits.

Sources:

SCFAs are powerful compounds produced in the gut when beneficial microbes break down dietary fibers. These acids primarily acetate, propionate, and butyrate improve fish digestion, boost immunity, and support growth.

Plant-Based Ingredients: Common feed ingredients like soybean meal, corn bran, wheat bran, and rice bran are rich in fermentable fibers that gut microbes convert into SCFAs. For example, soybean meal encourages the growth of bacteria like *Lactococcus lactis*, known for efficient fermentation. Similarly, corn and rice bran contain fibers like pectin and hemicellulose that microbes use to produce SCFAs.

- 1. Algae and Seaweed:** These natural prebiotics are rich in complex carbohydrates. Species like *Dunaliella salina* and *Nannochloropsis* have been shown to increase butyric acid levels in fish. Extracts from seaweed also help produce acetate and propionate, thanks to their low-molecular-weight polysaccharides.
- 2. Aquatic Plants:** Plants like duckweed, water hyacinth, water lettuce, and Azolla are underused yet fiber-rich. Some, like *Azolla pinnata*, have even shown greater probiotic activity than commercial ingredients, pointing to their potential in enhancing SCFA production naturally.
- 3. Probiotics and Prebiotics:** Adding good bacteria (probiotics) like *Lactobacillus* or *Bacillus* to fish diets can boost SCFA levels. Prebiotics, which are special dietary fibers, feed these microbes and increase SCFA production. Ingredients like inulin, fructooligosaccharides (FOS), and

arabinoxyloligosaccharides (AXOS) have all been shown to raise SCFA levels in fish and crustaceans.

- 4. Resistant Starch:** This type of starch bypasses digestion and is fermented in the hindgut. Sources like potato starch, lupin meal, and special maize types have been shown to increase SCFA levels, especially butyrate, which is key for gut health and tissue growth.

Fish Gut Microbiota and SCFA production-absorption mechanism:

The gut of fish are complex ecosystems, home to a variety of microorganisms that play a vital role in the health and metabolism of their host. These microbial communities are highly dynamic, shaped by factors like diet, habitat, and growth stage. Some microorganisms transiently pass through the gut via food or water, while others establish stable, beneficial relationships with the fish, contributing to its well-being. The composition of these microbial populations varies across different life stages, with newly hatched larvae hosting relatively low numbers of bacteria. However, as fish begin feeding and their morphology develops, microbial populations grow, and diversity increases. Moreover, microbial profiles can differ based on feeding habits such as carnivorous, herbivorous, and omnivorous fish all exhibit unique gut microbiota, which evolve with dietary changes and environmental adaptation. In addition to bacteria, other microorganisms, such as yeast, have been identified in fish guts, suggesting they may also play a role in gut health. Despite significant research on the human gut microbiome, much remains to be discovered about the microbial communities in fish. One of the most exciting areas of study is the production of SCFAs by gut microbes, including acetate, propionate, and butyrate. These SCFAs are produced when gut microbes' ferment undigested food components, such as fibers and amino acids. In fish, SCFAs are found predominantly in the distal intestine, particularly the colon, with minimal concentrations in the stomach due to its acidic environment. The production of SCFAs in fish depends on diet and microbial composition. Different bacteria specialize in converting substrates into various SCFAs, and the fermentation process can produce a wide range of compounds,

such as branched-chain fatty acids, phenols, amines, and indoles. The concentration and ratio of SCFAs can differ not only between species but also among individuals of the same species.

Acetate is generally the most abundant SCFA in fish, followed by propionate and butyrate. Acetate is mainly produced through the acetyl-CoA pathway, using dietary compounds like pyruvate. Butyrate is synthesized from acetate, lactate, or amino acids, through either the butyryl-CoA: acetate-CoA transferase or butyrate kinase pathways. Propionate production follows different routes, including succinate, acrylate, and propanediol pathways. Once produced, SCFAs are absorbed rapidly into the bloodstream via both active and passive transport mechanisms. Passive diffusion allows SCFAs in their non-ionic form to move across the gut lining, especially when the intestinal pH is favourable. Active transport, facilitated by protein carriers like monocarboxylate transporters (MCTs), also plays a crucial role in absorbing ionized SCFAs. Absorbed SCFAs are used in various metabolic processes. Acetate is involved in lipid synthesis and muscle development, while butyrate serves as an energy source for gut cells. Propionate has been linked to gluconeogenesis, the production of glucose from non-carbohydrate sources. Research on SCFAs in fish is still in its early stages, but it's clear that these compounds have significant impacts on fish health. They not only provide energy but also support vital processes such as water and salt balance by stimulating sodium and water absorption in the intestine. Understanding the production, absorption, and utilization of SCFAs could lead to innovative approaches in aquaculture, such as designing diets that promote beneficial microbial activity or using SCFA-producing probiotics to enhance fish growth and resilience. Ultimately, the gut microbiota of fish may hold the key to more sustainable and healthy farming practices, improving both productivity and environmental outcomes.

SCFAs as Natural Immune Booster and Growth Promoter:

In fish, several studies highlight the immunomodulatory power of SCFAs, making them promising natural alternatives to antibiotics. Butyrate, for example, has shown anti-

STRAWLAGE: FERMENTING A CIRCULAR ECONOMIC PATHWAY FOR SUSTAINABLE LIVESTOCK FEEDING

Yamini Khatri, Jannat Saini, Vishal and Nitin Tyagi*

INTRODUCTION

The poor productivity of livestock in tropical and sub-tropical countries stems largely from seasonal shortages of feed, both in quantity and quality with feed costs already making up over 70% of production expenses. Global fodder demand is projected to rise nearly 4.5% by 2030 (Tahir et al., 2024), a gap most acute in subtropical Asia, where smallholder systems dependent on crop residues and low-value seasonal forages face deficits that worsen in dry seasons (Mudau et al., 2021) and are further strained by climate variability. India illustrates the problem starkly: it holds just 2.29% of global land area yet supports 17.4% of the world's human population and 10.7% of its livestock, with shrinking grazing lands forcing farmers to ration feed toward lactating animals, leaving heifers and dry animals under-fed and unable to reach their genetic potential.

At the same time, India generates enormous agricultural surplus and residue. As the world's second-largest fruit and vegetable producer (about 355.25 million tonnes annually, with 5.6 million tonnes lost each year (Ministry of Agriculture & Farmers Welfare, 2024), and with crop production of roughly 723 million tonnes yielding around 585 million tonnes of residue, cereals account for 70% of this residue, rice alone contributing 34% (NPMCR, 2014). While residues are used for bedding, feed, biogas and fuel, about 151 million tonnes are burned annually to clear fields, rice being the largest contributor at 36% (Sahu et al., 2021). Environmental and fodder pressures that together have spurred research into alternative uses for paddy straw, even as its poor nutrient profile still limits its value as animal feed.

A HISTORY OF VALORIZATION OF STRAW

Historically, several approaches have been used to

THE SCALE OF THE OPPORTUNITY

70%+ of livestock production cost is feed and fodder	23.4% national dry-fodder deficit (ICAR-IGFRI, 2024)
126 MT paddy straw produced in India every year	4% and 45% CP and TDN of raw, untreated paddy straw respectively— too low to feed at scale

improve the feeding value of rice straw, broadly falling into physical, chemical and biological treatments, alongside its established use outside animal feed for compost, pulp and paper, construction material, soil enrichment, and fuel. Physical methods such as chopping and grinding reduce rumen retention time and improve intake, though finer grinding can lower digestibility by shortening rumination and microbial degradation. Chemical treatments, dating back to alkali-treated straw used during World War II feed shortages, use agents such as sodium hydroxide, ammonia, urea, chlorine or lime to break down lignin-hemicellulose-cellulose bonds and improve fibre accessibility, digestibility and milk yield, though urea treatment in particular has seen limited farmer adoption when used alone. Biological treatments using lignin-degrading fungi (as in India's pioneering Karnal process) or enzymes such as cellulases and xylanases, offer a cheaper, more environmentally friendly alternative, with recent work increasingly combining microbial inoculants with physical pretreatment, together illustrating a decades-long trajectory from simple mechanical processing toward increasingly targeted biological upgrading of straw's feeding value.

THE COST OF UNUSED RESOURCES

When a feed resource can't be fed, it becomes a disposal problem instead and both agriculture and agro-industry tend to manage it the fastest way available. On the farm side, roughly 151 million tonnes of India's crop residue is cleared from the field every year through open combustion, with rice straw the single largest contributor at 36% of that total; each tonne disposed of this way releases approximately 3 kg of particulate matter, 60 kg of carbon monoxide, over 14 kg of carbon dioxide and 2 kg of sulphur dioxide, a toll multiplied across an annual paddy straw output of 126 million tonnes and written into the air people breathe across an entire region every winter. A comparable disposal problem exists further along the value chain, in food and beverage processing. By-products such as wet distillers' grain, potato waste and pea pods are generated in large quantities and are highly perishable; in the absence of an established market, these residues are frequently discarded in landfills or left to decompose in open conditions. Owing to their high moisture and nutrient content, uncontrolled decomposition of these materials proceeds anaerobically, generating methane and contributing to greenhouse gas emissions through a pathway distinct from, but comparable in effect to, straw burning. Paddy straw and agro-industrial by-products can therefore be viewed as complementary underutilised resources: the former abundant but nutritionally deficient, the latter nutrient-dense but highly perishable, with neither viable as a stand-alone feed. It is this complementarity that strawlage production is designed to exploit, combining the two waste streams into a single, nutritionally corrected feed resource rather than allowing each to generate pollution independently.

Paddy straw is not a low-quality feed resource — it is an imbalanced one, abundant in carbohydrate and starved of protein and moisture. And unlike quality, an imbalance can be corrected.

CORRECTING THE IMBALANCE: HOW STRAWLAGE IS MADE

Ensiling, fermenting a moist feed under airtight, anaerobic conditions has long been used to preserve crops like maize, where naturally high moisture and

abundant fermentable sugars allow lactic acid bacteria (LAB) to quickly establish an acidic, oxygen-free environment that keeps the forage stable for months. Applying the same principle to a dry, fibrous residue like paddy straw is far harder, because straw arrives at the ensiling stage already working against nearly every condition fermentation depends on. It carries only 10–15% moisture, well short of the 60–65% that an active fermentation needs to get underway, and it offers LAB almost nothing to work with: virtually no digestible protein and very little of the water-soluble sugars these bacteria rely on as their primary energy source. Left on its own, straw's tough, silica-rich fibre further slows any microbial activity that does begin, so a straight attempt at ensiling raw straw tends to stall rather than ferment properly.

By-product	DM (%)	CP (%)	EE (%)	NDF (%)	ADF (%)
Wet distillers' grain	23.1	32–35	5.4	57.5	30.2
Paddy straw	89–91	4–4.5	1.5	70–75	45–50
Pea pods	10–12	18–20	1.05	49.50	35.2
Potato hash	15–20	8–10	10.43	27.5	16.5

Table 1. Chemical composition of ensiling by-products used to correct paddy straw's nutrient gaps.

Alongside these by-products, the process uses functional additives such as LAB inoculants, xylanase enzyme, and in select formulations molasses or urea, each playing a distinct role: fermentation stimulants (LAB, sugars, enzymes) drive lactic acid production; nutrient enhancers add readily fermentable substrates; and microbiological inoculants combine beneficial organisms to improve aerobic stability and reduce spoilage at feed-out. The bacterial inoculants combination including both homo and heterolactic bacteria should be used for further enhancing quality of ensiled strawlage. After thorough sampling from field, isolations and characterization the bacterial isolates are identified at ICAR-NDRI.

FROM SILO PIT TO BALE: A FIELD-READY FORMAT

Straw-based silages have traditionally been confined to pits, bags or drums formats that are

awkward to transport and slow to scale. The NDRI, Karnal team has now demonstrated strawlage production successfully in baled form: chopped, treated straw compacted and wrapped exactly like conventional commercial silage. This is the first time bale-form paddy strawlage has been achieved, and it matters because bales bring a set of practical advantages that pit- or drum-based ensiling simply cannot offer. They can be made, stacked, moved and sold using equipment and logistics the silage industry already has in place, removing the need for new infrastructure. Their compact, wrapped form allows for easy transport over long distances and flexible storage, whether at the farm gate, a cooperative yard, or a feed depot, without the space and construction demands of a permanent silo pit. Individual bales can be produced, opened and fed out one at a time, minimising exposure to air and reducing spoilage compared to a large pit that must be used up once opened. This modularity also makes strawlage far easier to trade in defined quantities, market commercially, and scale from a single farm to an industrial operation.



Strawlage bales ready for storage...



...and stacked for transport to the farm.

Under standard formulation, this becomes a complete total mixed ration (TMR) of roughly 40% dry matter and 12% crude protein, dense enough to serve as a stand-alone ration for low- to medium-yielding animals when paired with a mineral supplement, and consistently reaching well-defined fermentation quality benchmarks:

THE METHANE DIVIDEND

Improper disposal of agro-industrial wastes in landfills triggers anaerobic decomposition and significant methane release, so converting these residues into livestock feed through ensiling both reduces waste accumulation and cuts greenhouse

Quality parameter	Typical range achieved
pH	3.8 – 4.5
Lactic acid (% DM)	3.5 – 6.5
Water-soluble carbohydrates (g/DM)	15 – 20
NH ₃ -N (% DM)	0.18 – 0.21
Butyric acid (% DM)	≈ 0.01
In vitro DM digestibility (%)	54 – 60
Total digestible organic matter (%)	55 – 60

Table 2. Fermentation quality indices of well-prepared paddy straw silage/strawlage.

gas emissions, while improved feed quality can further reshape rumen fermentation to aid methane mitigation. Methane, which makes up roughly 12–17% of global GHG emissions (Beauchemin et al., 2009), arises mainly from enteric fermentation, the microbial breakdown of feed within an animal's digestive tract; ruminants are the primary contributors because their rumen enables fibrous plant material to be broken down into usable nutrients, though emissions depend as much on feed quality and intake as on this specialized anatomy, with lower-quality feed and higher intake driving higher methane output (Mangino, 2003). These emissions represent an energy loss equal to 2–12% of gross dietary energy intake (Hristov et al., 2015), so mitigating them offers a dual benefit: redirecting energy toward meat and milk production while easing climate impact (Eckard et al., 2010). Studies show that when beneficial anaerobic LAB silage inoculants establish themselves within the rumen microbial niche, they raise lactic acid levels, favouring lactate-utilising bacteria such as *Megasphaera elsdenii* and shifting fermentation toward propionate via the acrylate pathway, thereby lowering the acetate:propionate ratio and methane output while potentially inhibiting methanogens directly through bacteriocins and other metabolites. Pre-fermented feed has also been shown to reduce the extent of fermentation occurring within the rumen itself, further lowering methane emissions.

WHAT THIS MEANS FOR THE FEED INDUSTRY

For India's compound feed manufacturers, strawlage is best read as a sourcing and product opportunity rather than a research curiosity. It

offers an economical, locally available ingredient to buffer volatile grain and cake prices, while giving the industry a genuine, verifiable sustainability story residue valorisation, reduced burning, lower enteric methane, at a time when buyers, regulators and lenders are all beginning to ask for exactly that.

The economics favour scale. Agro-industrial by-products such as wet distillers' grain are bulky, high in moisture and short-lived spoilage can begin within five to seven days, so transporting them far from source quickly erodes any cost advantage, and the upfront investment in choppers, balers and storage is a real barrier for an individual smallholder. This points the opportunity squarely toward organised, entrepreneurial and industrial-scale operators: players who can co-locate processing near by-product sources, invest in baling and quality-control infrastructure, and move finished strawlage out through an established feed distribution network.

BACKBONE, NOT BURDEN

Animal agriculture has long underpinned India's

rural economy, sustaining household incomes through droughts, market fluctuations and the lean months between harvests. The evidence presented in this review indicates that the sector's future sustainability will continue to be determined by the same factor that has historically governed its performance: feed availability. A tonne of paddy straw represents either a source of seasonal air pollution through open burning or a substantial contribution toward closing the seasonal fodder deficit for dairy animals, with the latter pathway simultaneously addressing fodder scarcity, production cost and enteric methane emissions. Realizing this potential at a reliable, affordable and field-relevant scale, through the coordinated use of agro-industrial by-products, targeted microbial inoculants and baling technology is central to repositioning animal agriculture from a constraint on sustainable development to one of its principal enabling components.

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Blueline Foods India Pvt. Ltd.	42
Camlin Fine Sciences Ltd.....	C3
Cargill India Pvt. Ltd.....	14
Ceva Polchem Pvt. Ltd.....	43
Coastal Exports Corporation	34
Cremach Pvt. Ltd.....	44
Evonik India Pvt. Ltd.	35
Godrej Agrovat Ltd.	2
Gyandhara Industries Pvt. Ltd.....	16
Hindustan Equipment Pvt. Ltd.	C5-C6
Huvepharma SEA (Pune) Pvt. Ltd.	36
Indian Poultry Equipment Manufacturers Association	3
Intervet India Pvt. Ltd.....	C4
Kemin Industries South Asia Pvt. Ltd.....	37
Nanda Feeds Pvt. Ltd.	18
Natural Remedies Pvt. Ltd.	20
Neotech Projects Pvt. Ltd.....	45
Noble Animal Health Pvt. Ltd.....	46
Noveltech Feeds Pvt. Ltd.	22
Nurture Aqua Technology Pvt. Ltd.	38
Pranav Bitek Agrotech Pvt. Ltd.....	39
R. G. Sundar & Co	C2
RSD Trading & Distribution	47
Shalimar Pellet Feeds Ltd.	24
Shanthi Feeds Pvt. Ltd.	40
Shivshakti Agro (India) Pvt. Ltd.	26
Srinivasa Farms Pvt. Ltd.	27
U. S. Soybean Export Council, Inc (USSEC)	6
U.S. Grains & BioProducts Council	7
Value Consultants	48



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