

SUSTAINABLE ANIMAL NUTRITION AND ITS IMPLICATIONS FOR ENVIRONMENTAL AND HUMAN HEALTH: A ONE HEALTH REVIEW

Ioan-Ștefan PRICOP^{1#}, Cosmin ȘONEA¹, Dana TĂPĂLOAGĂ¹, Paul-Rodian TĂPĂLOAGĂ¹, Maria-Teodora PIȚURU¹, Dimitrie-Vlad NEAGU¹, Cristinel Gigi ȘONEA², Gheorghe Valentin GORAN¹, Alice Elena MUNTEANU³

¹ University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăști Blvd, District 1, Bucharest, Romania

² Bioteria University – Bucharest, Str. Garlei no. 81, sector 1, Romania, 3.TITU MAIORESCU Universitatea Str. Dâmbovnicului 22, sector 4, București,

REVIEW ARTICLE

Abstract

The growing global demand for animal-derived foods places increasing pressure on food systems, with significant implications for environmental sustainability and human health. This review integrates current knowledge on sustainable animal nutrition within a One Health framework, highlighting the interconnected relationships between animal production, ecosystem health, and public health outcomes. Special emphasis is placed on recent research findings regarding alternative feed resources, feed additives, precision feeding, and circular economy approaches.

Evidence from recent studies demonstrates that incorporating alternative feed sources such as insects, microalgae, agro-industrial by-products, and former food products can significantly reduce reliance on human-edible crops while improving resource efficiency. Research results further indicate that feed additives, including methane inhibitors and bioactive compounds, can effectively decrease enteric methane emissions and enhance nutrient utilization. Precision feeding strategies, supported by digital technologies, have been shown to optimize feed efficiency and reduce environmental burdens.

Life Cycle Assessment (LCA) studies consistently report measurable reductions in greenhouse gas emissions, land use, and water consumption when sustainable feeding strategies are implemented. In parallel, research highlights improvements in the nutritional quality of animal-derived products, including enhanced profiles of essential amino acids, micronutrients, and bioactive compounds, while reducing risks associated with antimicrobial residues and contaminants.

Despite these advances, challenges such as economic constraints, variability of alternative feeds, and regulatory barriers persist. Overall, current evidence supports that sustainable animal nutrition, guided by One Health principles, offers a viable pathway to improve livestock productivity, reduce environmental impacts, and enhance food safety, contributing to more resilient and sustainable food systems.

Keywords: alternative feed resources, precision feeding, feed additives, food safety, One Health

#Corresponding author: cosmin.sn@yahoo.com

INTRODUCTION

The global demand for animal-sourced foods is increasing rapidly due to population growth, urbanization, and rising incomes, creating significant pressure on food systems worldwide (Espinosa-Marrón et al., 2022; FAO, 2006). The livestock sector contributes substantially to greenhouse gas emissions, land use, and water consumption, posing serious environmental challenges (Kebreab et al., 2026). At the same time, ensuring the nutritional quality and safety of animal-derived products is critical for human health, including the supply of essential proteins, micronutrients, and bioactive compounds (Varijakshapanicker et al., 2019; Pinotti et al., 2025). In this context, the One Health approach provides a comprehensive framework to address

the interconnected challenges of animal, human, and environmental health (Gheorghe-Irimia et al., 2024; Lane et al., 2025). One Nutrition further emphasizes the integration of crop production, animal feeding strategies, and human nutrition to optimize resource use, reduce environmental impacts, and enhance food quality (Pinotti et al., 2025; Govoni et al., 2025). The objective of this review is to integrate current knowledge on sustainable animal nutrition and its implications for environmental sustainability and human health from a One Health perspective. The review pays particular attention to alternative feed resources, feed additives, circular economy approaches, and precision feeding strategies (Tretola et al., 2025; Albark et al., 2025; Moorby, 2021; Gil et al., 2024).

MATERIAL AND METHOD

This study is based on a comprehensive literature review of recent scientific publications focusing on sustainable animal nutrition and its implications for environmental sustainability and human health. Relevant peer-reviewed articles, reports, and reviews were selected based on their scientific relevance, methodological robustness, and recency. The analysis included studies addressing key topics such as alternative feed resources, feed additives, precision feeding strategies, and circular economy approaches. In addition, studies employing life cycle assessment (LCA) methodologies were considered to evaluate environmental impacts associated with different feeding systems (Espinosa-Marrón et al., 2022). The collected data were systematically analyzed and synthesized within a One Health framework, allowing the identification of interactions between animal nutrition, environmental sustainability, and human health outcomes.

RESULTS AND DISCUSSIONS

Livestock production faces a major challenge in the competition between food for humans and feed for animals, as conventional diets rely heavily on cereals and soy, increasing pressure on arable land and contributing to food insecurity in vulnerable regions (Pinotti et al., 2025; Espinosa-Marrón et al., 2022). Animal feeding significantly influences environmental impacts, including greenhouse gas emissions from ruminants, deforestation for feed production, and nutrient pollution from manure and fertilizers, which affect ecosystems and water quality (Kebreab et al., 2026; Tretola et al., 2025). Current nutritional practices may also pose risks to public health, contributing to antimicrobial resistance and increasing the risk of zoonotic diseases, particularly in intensive production systems characterized by high animal densities (Gheorghe-Irimia et al., 2024; Lane et al., 2025). A comparison between intensive and traditional systems highlights important trade-offs: intensive systems are more productive but associated with higher environmental and epidemiological risks, while traditional systems are less efficient but exert lower environmental pressure (Varijakshapanicker et al., 2019; Pinotti et al., 2025; Şonea et al., 2024). Animal diets directly influence metabolic processes and the production of gases and pollutants. High-fiber diets in ruminants contribute to enteric methane production, while protein-rich diets increase nitrogen and phosphorus

excretion, contributing to environmental pollution (Şonea et al., 2024; Kebreab et al., 2026; Albarki et al., 2025). At the same time, nutrients and other compounds from feed are transferred into animal-derived products, influencing their nutritional quality and safety (Tretola et al., 2025; Govoni et al., 2025). Recent research highlights several strategies for sustainable animal nutrition (Govoni et al., 2025; Tretola et al., 2025; Pinotti et al., 2025; Kebreab et al., 2026). Feed additives such as 3-nitrooxypropanol, bioactive compounds, and microbial interventions have been shown to reduce enteric methane emissions and improve nutrient utilization (Albarki et al., 2025; Buonaiuto et al., 2025). Precision feeding strategies optimize feed efficiency and reduce environmental burdens (Moorby, 2021; Ojha, 2026). Circular and integrated crop-livestock systems further enhance sustainability (Kebreab et al., 2026; Govoni et al., 2025). Case studies demonstrate practical applications (Tretola et al., 2025; Albarki et al., 2025; Gil et al., 2024). Environmental assessments show that sustainable feeding strategies significantly reduce greenhouse gas emissions, land use, and water consumption (Espinosa-Marrón et al., 2022; Kebreab et al., 2026). From a human health perspective, sustainable animal nutrition improves the quality of animal-derived products (Pinotti et al., 2025; Varijakshapanicker et al., 2019; Gheorghe-Irimia et al., 2024; Lane et al., 2025). Trade-offs between productivity, environmental impact, and health risks must be carefully managed (Kebreab et al., 2026; Albarki et al., 2025; Perkins et al., 2025). Future research should focus on improving circular nutrition systems (Tretola et al., 2025; Albarki et al., 2025; Ojha, 2026; Şonea et al., 2025).

CONCLUSIONS

Sustainable animal nutrition represents a critical strategy to address the interconnected challenges of environmental sustainability, animal productivity, and human health. By incorporating alternative feed resources, feed additives, precision feeding, and circular economy approaches, livestock systems can reduce greenhouse gas emissions, optimize land and water use, and enhance nutrient recycling (Kebreab et al., 2026; Govoni et al., 2025; Tretola et al., 2025). These strategies also improve the nutritional quality and safety of animal products, ensuring high-quality proteins, essential micronutrients,

and bioactive compounds, while mitigating risks from antimicrobial residues, zoonotic pathogens, and other contaminants (Pinotti et al., 2025; Gheorghe-Irimia et al., 2024; Varijakshapanicker et al., 2019). A One Health perspective highlights the interdependence of animal nutrition, environmental health, and public health, emphasizing the need to balance productivity, sustainability, and safety through interdisciplinary collaboration and integrated policies (Lane et al., 2025; Perkins et al., 2025; Albarki et al., 2025). Despite these advances, challenges remain, including feed variability, cost, consumer acceptance, and regulatory barriers. Future research and implementation should focus on scalable circular nutrition systems, innovative feed additives, and rigorous monitoring of environmental and human health outcomes to fully realize the potential of sustainable animal nutrition (Ojha, 2026; Gil et al., 2024; Pinotti et al., 2025).

Overall, sustainable animal nutrition guided by One Health principles provides a pathway to resilient, low-impact livestock systems that support both planetary and human health.

REFERENCES

- Albarki, H.R., Suntara, C., Wongtang-Tintharn, S., et al., 2025. Sustainable animal nutrition and feeding strategies for reducing methane emissions and enhancing feed digestibility with encapsulated black soldier fly larvae oil. *Sustainability*, 17, 3155.
- Altshuler, Y., Calvao Chebach, T., Cohen, S., 2023. AI-based predictive modeling of feed additive efficacy.
- Buonaiuto, G., et al., 2025. Bioactive feed additives in animal nutrition. *Frontiers in Veterinary Science*.
- Espinosa-Marrón, A.E., Adams, K.A., et al., 2022. Environmental impact of animal-based food production and the feasibility of a shift toward sustainable plant-based diets. *Frontiers in Sustainability*.
- Gheorghe-Irimia, R.-A., Şonea, C.G., Gurău, M.R., Şonea, C., Tăpăloagă, D., Pîţiu, A.-M., Tăpăloagă, P.-R., 2024. One Health solution for a safer plate: Addressing cross species pathogen transmission in global food systems. *Analele Universităţii din Oradea, Fascicula Ecotoxicologie, Zootehnie şi Tehnologii în Industria Alimentară*, 23.
- Gheorghe-Irimia, R.-A., Şonea, C., Tăpăloagă, D., Gurău, M.R., Ilie, L.-I., Tăpăloagă, P.-R., 2023. Innovations in dairy cattle management: Enhancing productivity and environmental sustainability. *The Annals of Valahia University of Târgovişte*.
- Gheorghe-Irimia, R.-A., Tăpăloagă, D., Şonea, C., Al Dulaimi, M.K.H., Usturoi, A., Tăpăloagă, P.-R., 2025. Strategies for mitigating methane emissions in cattle: Advancing sustainable livestock production. *Scientific Works. Series C. Veterinary Medicine*, LXXI(2).
- Gil, M., Rudy, M., Duma-Kocan, P., et al., 2024. Sustainability of alternatives to animal protein sources, a comprehensive review. *Sustainability*, 16(17), 7701.
- Govoni, C., Ottoboni, M., Manoni, M., Pinotti, L., Rulli, M.C., 2025. Upcycling former food products in livestock diets: A One Health approach to prevent resource depleting farming systems. *Resources, Conservation and Recycling*, 223.
- Kebreab, E., Pressman, E.M., Meo-Filho, P., Lucas, K.R.G., 2026. Sustainable ruminant production: Circular systems, nutrition, and methane mitigation. *Animal*.
- Lane, J.K., Kelly, T., Bird, B., Chenais, E., Roug, A., Vidal, G., Gallardo, R., Zhou, H., Vanhoy, G., Smith, W., 2025. A One Health approach to reducing livestock disease prevalence in developing countries: Advances, challenges, and prospects. *Annual Review of Animal Biosciences*, 13, 277–302.
- Moorby, J.M., 2021. New feeds and new feeding systems in intensive and semi-intensive systems.
- Ojha, S., 2026. Mitigating greenhouse gas emissions through livestock strategies within a planetary health framework. *Human Ecology Review*.
- Parlasca, M.C., Qaim, M., 2023. Meat consumption and sustainability: Review on meat sustainability, environment, and health impacts. *Annual Review of Resource Economics*, 15, 1–25.
- Perkins, L.S., Barnes, K.D., Cristobal, O., Dimonaco, N.J., Godoy Santos, F., Kyriazakis, I., Lawther, K., Lively, F.O., Morrison, S.J., Nugent, A.P., Scollan, N.D., Theodoridou, K., Woodside, J.V., Yan, T., 2025. Challenges and innovations for sustainable ruminant production based upon One Health principles. *Proceedings of the Nutrition Society*, 1–13.
- Pinotti, L., Cheli, F., Govoni, C., Rulli, M.C., Premarajan, P., Cattaneo, D.M.I.R., 2025. The 'One Nutrition' approach: Connecting crop production, animal nutrition and human nutrition. *Italian Journal of Animal Science*, 24(1), 978–987.
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., 2006. *Livestock's long shadow: Environmental issues and options*. Rome: Food and Agriculture Organization of the United Nations.
- Şonea, C., Gheorghe-Irimia, R.-A., Tăpăloagă, D., Tăpăloagă, P.-R., 2024. Nutrition and animal agriculture in the 21st century: A review of

-
- future prospects. *Annals of the Academy of Agricultural and Forestry Sciences*.
- Șonea, C., Tăpăloagă, D., Lazăr, Ș., Jerca, O., Gheorghe-Irimia, R.-A., Pițiu, A.-M., Tăpăloagă, P.-R., 2024. Manure management in livestock systems: Assessing One Health impacts on environmental contamination and human exposure. *Analele Universității din Oradea, Fascicula Ecotoxicologie, Zootehnie și Tehnologii în Industria Alimentară*, 23(Part A), 151.
- Șonea, C.G., Porca, M.M., Sîrbu, M., Ploșteanu, M.G., Coțianu, R.D., 2025. The “One Health” concept in the field of agriculture. *Annals of the University of Oradea, Fascicle: Ecotoxicology, Animal Science and Food Science and Technology*.
- Te Pas, M.F.W., Veldkamp, T., De Haas, Y., et al., 2021. Adaptation of livestock to new diets using non-human edible protein sources — A review. *Animals*, 11(8).
- Tretola, M., Lin, P., Eichinger, J., Manoni, M., Pinotti, L., 2025. Review: Nutritional, safety, and environmental aspects of former food-stuff products in ruminant feeding. *Animal*.
- Varijakshapanicker, P., et al., 2019. Sustainable livestock systems to improve human health and reduce environmental impacts. *Frontiers in Sustainable Food Systems*, 3, 45.