

Sustainable Livestock Systems to Improve Human Health, Nutrition, and Economic Status – An Article Review

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Abstract

Sustainability issues related to livestock have been discussed primarily with an emphasis on their environmental effects without sufficient consideration for nutrition and other socio-economic factors. The purpose of this article review is to analyze the paper by Varijakshapanicker et al. (2019) that highlights the potential of livestock as a critical resource in enhancing the health of humans, food and nutritional security, and economic stability in developing countries. In the reviewed paper, the authors make use of the results obtained in the areas of nutrition science, environmental science, and developmental economics to elaborate on the role of livestock as an asset in terms of providing livelihood opportunities in rural areas, ecosystem services, and converting non-food biomass resources to food products. At the same time, the paper identifies several problems, including greenhouse gas emissions, inequitable distribution of food resources, and sociocultural obstacles associated with the consumption of animal-source foods. In summary, the paper provides a vital contribution to the literature through its balanced approach to sustainability that accounts for both environmental and nutritional factors.

Keywords: Sustainable Livestock, Animal-Sourced Foods, Human Nutrition, Food Security, Economic Development, Greenhouse Gas Emissions

1. Introduction

Sustainable livestock systems are increasingly examined within the broader discourse of sustainable development because they affect environmental integrity, economic viability, social equity, public health, nutrition, and rural livelihoods. While livestock production is often criticized for greenhouse gas emissions, land degradation, biodiversity loss, and resource use, the reviewed literature argues that livestock should not be evaluated only through environmental costs. Instead, its multifunctional role in food security, nutrient provision, livelihood generation, cultural identity, ecosystem services, and community resilience must also be considered, particularly in low- and middle-income countries (Varijakshapanicker et al., 2019).

Global sustainability requires responsible use of resources such as energy, water, food, space, and human capacity to support development goals. Livestock production systems are often viewed as environmentally problematic because of their contribution to GHGs, land degradation, and biodiversity loss. However, Varijakshapanicker et al. (2019) emphasize that such criticisms may overlook the multifunctionality of livestock in Low and Middle-Income Countries, where livestock provide food, protein, income, cultural value, and community resilience. The study therefore frames livestock systems through a holistic sustainability approach, arguing that environmental outcomes should not be judged only through emissions or GHGs, but also through nutrient density, protein availability, and ecosystem services.

The literature presents sustainable livestock production as a balance among ecological health, economic profitability, and social acceptability. According to Varijakshapanicker et al. (2019), livestock systems differ widely, from extensive grassland systems to small landless production systems, and their sustainability depends heavily on management practices. Poorly managed systems may contribute to environmental degradation, biodiversity loss, and GHG emissions, while properly managed systems may support carbon sequestration, nutrient cycling, and land productivity. Mottet and Steinfeld (2018) argue that emission intensity provides a more accurate measure of livestock system efficiency than total GHG emissions alone, since production efficiency can reduce emissions without necessarily compromising food supply. Livestock also contribute to environmental sustainability through the conversion of grass, crop residues, and non-food biomass into nutrient-dense foods that humans cannot directly consume (Mottet et al., 2017; Varijakshapanicker et al., 2019). Properly managed grazing systems may reduce soil erosion and improve soil carbon sequestration (Gosnell et al., 2020), while silvopastoral systems may enhance biodiversity, soil carbon storage, and productivity by integrating trees,

forage crops, and livestock (Feliciano et al., 2018). However, the literature also notes that poorly maintained grazing systems may result in overgrazing, compacted soils, desertification, land degradation, methane emissions, water consumption, nutrient runoff, and ecosystem damage. Animal-source foods (ASFs) are also emphasized for their nutritional value, particularly among vulnerable populations. ASFs provide protein, essential fatty acids, iron, zinc, B12 vitamins, calcium, and iodine, which are important for child growth, cognitive development, immune function, and micronutrient adequacy. Studies from countries such as Kenya, Ecuador, India, and Nepal suggest that ASF consumption is associated with better growth, cognitive development, and reduced stunting among children (Iannotti et al., 2017). However, according to Eaton et al., 2019, evidence from systematic reviews on ASF consumption and child growth remains limited in quantity and quality. Health effects also vary by population, diet, and disease context, as shown by the mixed evidence on dairy intake and prostate cancer risk (Lopez-Plaza et al., 2019). Dairy products are linked with calcium and other nutrients important for bone health, and evidence suggests possible reductions in osteoporosis and type 2 diabetes risks (Rozenberg et al., 2016; Varijakshapanicker et al., 2019).

The discussion is especially relevant to low- and middle-income countries where livestock systems support food security, rural livelihoods, and economic stability. The livestock value chain contributes to employment through collection, processing, transport, storage, and retail, while livestock may provide more stable income than crop-based systems (Varijakshapanicker et al., 2019). However, smallholder producers remain vulnerable to disease outbreaks, zoonotic risks, price volatility, rising feed costs, supply chain disruptions, weak veterinary systems, and limited insurance access. At the household and community level, access to ASFs is shaped by poverty, food prices, market conditions, income inequality, nutrition education, and sociocultural practices. Lower-income households may prioritize cheaper, energy-dense foods over nutrient-dense ASFs (Varijakshapanicker et al., 2019). Cultural restrictions and unequal household food allocation may also limit women's and children's access to ASFs, especially when adult males receive food first within households (Gitelson and Vastine, 2003; Varijakshapanicker et al., 2019). These conditions show that livestock availability does not automatically ensure equitable ASF consumption.

The conceptual basis of the study is grounded in a systems-based and holistic sustainability perspective. Rather than treating livestock production as solely an environmental issue, the framework integrates environmental performance, nutrition, food security, affordability, cultural acceptability, livelihood generation, and ecosystem services. Varijakshapanicker et al. (2019) argue that sustainability should be assessed through multiple indicators, including emission intensity, nutrient density, protein availability, ecosystem services, equity, and economic outcomes. This interdisciplinary approach draws from nutrition science, environmental science, agricultural economics, and public health to examine livestock systems within wider sustainability frameworks.

The literature reveals several gaps that justify the need for a balanced review of sustainable livestock systems. First, many discussions focus heavily on GHG emissions while giving insufficient attention to nutrition, health, livelihoods, and socio-economic outcomes. Second, existing empirical studies are often observational, making it difficult to establish causality between animal product consumption, nutrition outcomes, and environmental impacts. Third, some studies are context-specific to LMICs, limiting generalizability to other agricultural and economic settings. Fourth, nutrition outcomes are measured inconsistently across studies, with some focusing on protein and micronutrient deficiencies while others use broader health indicators. There is also limited country-level information on the broader employment effects of livestock systems, which affects policy development and investment priorities. Moreover, although livestock productivity may improve food supply and livelihoods, expansion may also intensify ecological pressures if not carefully managed. Therefore, the rationale of the study is to assess livestock sustainability through a more balanced lens that considers both ecological costs and human development benefits.

The study aligns strongly with SDG 2 – Zero Hunger because livestock production provides nutrient-rich foods that can help address malnutrition and food insecurity. It also supports SDG 1 – No Poverty and SDG 8 – Decent Work and Economic Growth because livestock value chains generate employment and diversify income sources in rural communities (Varijakshapanicker et al., 2019). The study also connects with SDG 3 – Good Health and Well-Being through its discussion of ASFs, micronutrient intake, child growth, immune function, and diet-related health outcomes. At the same time, the paper recognizes possible tensions with SDG 13 – Climate Action, SDG 12 – Responsible Consumption and Production, and SDG 15 – Life on Land because expanded livestock production may increase land use, water demand, greenhouse gas emissions, and pressure on biodiversity. Thus, the study emphasizes that livestock-related sustainability must consider both human development goals and ecological limits.

This study is important to multidisciplinary sustainability because it connects agriculture, public health, nutrition, economics, environmental management, and social equity. Its contribution lies in showing that livestock systems should not be assessed only through emissions, but also through their role in food security, micronutrient access, livelihood development, ecosystem services, and rural resilience. At the same time, the study recognizes that these benefits must be weighed against environmental risks such as GHG emissions, land degradation, water use, biodiversity loss, and waste

management concerns. The study contributes to public health sustainability by examining the role of ASFs in improving nutrition among vulnerable groups. It supports socio-economic sustainability by highlighting livestock as a source of income, employment, and rural economic activity. It contributes to environmental sustainability by discussing emission intensity, carbon sequestration, silvopastoral systems, and resource efficiency. Finally, it contributes to policy and governance sustainability by emphasizing the need for context-specific, interdisciplinary strategies that integrate livestock development, nutrition education, social protection, market access, veterinary support, and fair food distribution.

2. Material and methods

2.1 Research Design

The study employed an article review design. Although the reviewed article by Varijakshapanicker et al. (2019) was not strictly a systematic review, it used an interdisciplinary approach to synthesize evidence from peer-reviewed empirical studies, meta-analyses, global datasets from the Food and Agriculture Organization (FAO), UNICEF, and the World Bank, and policy reports. This approach allowed the review to connect findings from nutrition science, environmental science, agricultural economics, and public health within the broader framework of livestock sustainability.

2.2 Locale of the Study

The study did not identify a specific physical locale because it reviewed literature and datasets related to livestock systems in broader global and regional contexts. The discussion focused particularly on low- and middle-income countries, where livestock systems are closely linked to food security, nutrition, livelihood opportunities, and environmental sustainability.

2.3 Respondents of the Study

The study did not involve direct human respondents. Instead, it reviewed and analyzed existing literature, empirical studies, global datasets, meta-analyses, and policy reports relevant to sustainable livestock systems and their implications for health, nutrition, environment, and economic development.

2.4 Sample and Sampling Procedure

The manuscript did not specify a formal sample size or sampling procedure. Since the article was not conducted as a strict systematic review, there was limited information on inclusion and exclusion criteria or bias evaluation. The reviewed evidence included interdisciplinary sources, but the absence of a systematic review protocol created variability in study design, research quality, and contextualization.

2.5 Research Instrument

No structured research instrument was used. The study relied on documentary and literature-based sources, including peer-reviewed empirical studies, meta-analyses, global datasets, and policy reports. These sources were used to examine the role of livestock systems in food security, environmental sustainability, nutrition outcomes, and socio-economic development.

2.6 Data Gathering Procedure

Data were gathered through the review and synthesis of existing literature and datasets. The article examined evidence from multiple disciplines to assess livestock systems in relation to nutrition, environmental effects, health outcomes, cultural and economic influences on food consumption, and sustainability issues in LMICs. The review also considered the methodological limitations of the studies used, including the reliance on observational research, context-specific data, and inconsistent measures of nutrition outcomes.

2.7 Data Analysis Techniques

The study used narrative and critical synthesis as its main analytical approach. Evidence from various sources was analyzed to identify the strengths, limitations, and implications of livestock systems for food security and environmental sustainability. The analysis also considered methodological weaknesses, such as the difficulty of establishing causality between animal product consumption, nutritional results, and environmental impacts. The review noted that differences in outcome measures, especially between studies focused on protein intake, micronutrient deficiencies, and broader health indicators, made cross-study comparisons difficult. Future longitudinal and randomized control studies were recommended to better understand nutrition and health outcomes associated with livestock-based production systems.

3. Results and Discussion

3.1 Major Themes in Sustainable Livestock Systems

3.1.1 Sustainability and Livestock Production Systems

The review found that sustainable livestock production systems require a balance among ecological health, economic profitability, and social acceptability. According to Varijakshapanicker et al. (2019), livestock systems differ widely in sustainability because they range from extensive grassland systems to small landless production systems. Poorly managed

systems may contribute to environmental degradation, biodiversity loss, and GHG emissions, while properly managed systems may support carbon sequestration, nutrient cycling, and improved land productivity. This finding suggests that livestock sustainability should not be judged only through total GHG emissions. Mottet and Steinfeld (2018) emphasized emission intensity as a more accurate basis for evaluating production efficiency because some systems, particularly in low- and middle-income countries, may produce higher emissions due to inefficiency. However, the review also noted that intensification may increase dependence on industrial feed, water, energy, and waste management systems, indicating the need for a more balanced assessment of both nutritional-economic benefits and ecological costs.

3.1.2 Environmental Contributions and Ecosystem Services

The review showed that sustainable livestock systems may provide environmental benefits through efficient resource use and ecosystem services. Livestock can convert grasses and crop residues that humans cannot consume into nutrient-dense foods (Mottet et al., 2017; Varijakshapanicker et al., 2019). Properly managed grazing systems may also reduce soil erosion and increase soil carbon sequestration, thereby contributing to climate change mitigation (Gosnell et al., 2020). Integrated systems such as silvopastoral production may further enhance biodiversity, soil carbon sequestration, and productivity (Feliciano et al., 2018). These findings indicate that livestock systems may contribute positively to environmental sustainability when properly managed. However, the review also recognized that poorly maintained grazing systems may lead to overgrazing, soil compaction, desertification, degraded land, methane emissions, water consumption, nutrient runoff, and ecosystem damage. Therefore, livestock sustainability assessments should include not only emissions per unit of food produced, but also the long-term ecological effects of livestock expansion and management quality.

3.1.3 Livestock and Human Nutrition

The review identified the nutritional value of animal-source foods as one of the strongest contributions of livestock systems. ASFs provide high-quality protein, essential fatty acids, and micronutrients such as iron, zinc, B12 vitamins, calcium, and iodine, which are particularly important during the first 1,000 days of life. Studies from Kenya, Ecuador, India, and Nepal indicated that ASF consumption may support better growth, cognitive development, and reduced stunting among children (Iannotti et al., 2017). This finding supports the argument that livestock systems should not be evaluated only by environmental cost because ASFs provide nutritional benefits that are difficult to replace in nutritionally vulnerable populations. However, the review also noted that evidence on the relationship between ASF consumption and child growth remains limited in quantity and quality according to Eaton et al., 2019. Thus, the nutritional benefits of ASFs should be interpreted alongside affordability, market access, and economic inequality, since nutritional value alone does not guarantee improved health outcomes.

3.1.4 Health Implications of Animal-Sourced Foods

The review found that ASFs provide nutrients that support immune function, bone development, and protection against nutrient deficiency. Dairy products were identified as major sources of calcium and other nutrients needed for bone health, and evidence suggests that regular dairy consumption may reduce the risk of osteoporosis and type 2 diabetes (Rozenberg et al., 2016; Varijakshapanicker et al., 2019). The health implications of ASFs remain context-dependent. The review noted that evidence on milk consumption and prostate cancer risk is inconsistent, with findings varying according to consumption level, population risk profile, and study design (Lopez-Plaza et al., 2019). This indicates that ASF consumption should be guided by moderation and context-specific dietary recommendations rather than extreme inclusion or exclusion. The review also recognized the need to consider concerns about excessive intake of processed meat and its possible links to non-communicable diseases.

3.1.5 Economic Impacts and Livelihoods

The review found that livestock value chains contribute to economic development through production, collection, processing, transport, storage, and retail activities. Dairy market systems, for instance, create non-farm employment and support rural economies. Livestock systems may also provide a more stable income source than crop-based systems (Varijakshapanicker et al., 2019). However, the review noted that broader country-level employment impacts remain insufficiently documented. This finding shows that livestock can function as an economic asset, particularly for rural households and smallholder producers. However, the review also emphasized that livestock-dependent systems face vulnerabilities such as disease outbreaks, zoonotic risks, price volatility, rising feed costs, supply chain disruptions, weak veterinary services, and limited insurance. Therefore, livestock should be understood both as a livelihood opportunity and as a sector exposed to biological and market-based risks.

3.1.6 Consumption Patterns and Sociocultural Constraints

The review found that ASF consumption is shaped by income, food prices, household purchasing power, nutrition knowledge, and sociocultural practices. Lower-income households often choose cheaper high-calorie foods instead of nutrient-dense ASFs because ASFs are more expensive than staple plant-based foods (Varijakshapanicker et al., 2019). In addition, cultural food restrictions and household food allocation practices may limit women's and children's access to ASFs, especially when adult males receive food first (Gitelson and Vastine, 2003; Varijakshapanicker et al., 2019). These

findings show that livestock availability does not automatically lead to equitable ASF consumption. The review suggests that improving production alone is insufficient if affordability, cultural barriers, and intra-household distribution are not addressed. Targeted subsidies, nutrition-sensitive cash transfers, vouchers, school feeding programs, maternal nutrition education, and community-level nutrition education may help improve ASF access among nutritionally vulnerable groups.

3.1.7 Pathways to Improve ASF Consumption

The review found that improving ASF consumption requires both supply-side and demand-side interventions. On the demand side, education and counseling can improve awareness of the nutritional value of ASFs during critical maternal and child life stages, while also addressing misinformation and cultural restrictions (Varijakshapanicker et al., 2019). On the supply side, improved veterinary services, feed efficiency programs, market infrastructure, targeted nutrition subsidies, and school feeding initiatives may increase livestock productivity, reduce costs, and improve access. This finding indicates that nutrition outcomes depend on coordinated action across agriculture, health, and social protection sectors. Agricultural interventions must be combined with behavior-change strategies that promote equitable household distribution of ASFs, especially for pregnant and lactating women and young children (Varijakshapanicker et al., 2019). Without such coordination, increased ASF production may mainly benefit markets rather than improving household dietary intake and nutrition.

3.1.8 Livestock and the Sustainable Development Goals

The review found that sustainable livestock systems are linked to several Sustainable Development Goals because they contribute to nutrition, health, livelihoods, and ecosystem management. Livestock production supports SDG 2 through nutrient-rich foods that help address malnutrition, and it is also associated with SDG 1 and SDG 8 because livestock value chains create employment and diversify rural income sources (Varijakshapanicker et al., 2019). The review also emphasized that sustainability should integrate environmental performance with nutrition, equity, affordability, and cultural acceptability (Varijakshapanicker et al., 2019). The finding highlights both the contribution and complexity of livestock systems within sustainable development. Expanding livestock production to support food security and poverty reduction may create tensions with SDG 13, SDG 12, and SDG 15 because of possible increases in land use, water demand, and greenhouse gas emissions. Therefore, livestock-related policies must carefully balance nutrition and income gains with ecological integrity.

3.2 Critical Synthesis of the Findings

The review found that Varijakshapanicker et al. (2019) used a systems approach to examine livestock sustainability by considering production efficiency, environmental effects, nutrition, health, and livelihood outcomes. A key finding was the importance of emission intensity rather than total emissions alone, as this allows better comparison among livestock systems with different productivity levels. The authors suggested that food security and environmental sustainability may be aligned through improved productivity and better livelihoods. This synthesis shows that the article offers a broad and interdisciplinary sustainability framework, but also requires careful interpretation. While emission intensity is useful, total livestock expansion may still increase ecological pressure. Similarly, while ASFs may improve micronutrient intake, growth, and cognitive development, nutrition outcomes remain affected by affordability, gender-based food allocation, market distribution, and sociocultural constraints. Thus, the relationship among environmental sustainability, nutrition, and economic development is not automatic and must be evaluated according to local context and policy conditions.

3.3 Overall Interpretation

The overall result of the review indicates that sustainable livestock systems can support human nutrition, public health, rural income, and environmental stewardship when they are properly managed and supported by context-appropriate policies. The article contributes to sustainability literature by moving the discussion beyond emissions alone and by emphasizing the multifunctionality of livestock systems in low- and middle-income countries. At the same time, the discussion shows that livestock sustainability involves trade-offs. The benefits of livestock for nutrition and livelihoods must be weighed against risks related to GHG emissions, land degradation, water use, biodiversity loss, disease outbreaks, market instability, and unequal food access. Therefore, sustainable livestock development requires integrated policies that combine agricultural productivity, environmental safeguards, nutrition education, social protection, veterinary support, and equitable food distribution.

4. Conclusion & Recommendations

The article by Varijakshapanicker et al. (2019) contributes significantly to the literature on sustainable livestock systems by presenting livestock farming not only as an environmental concern but also as a pathway for improving human nutrition, health, rural income, and environmental stewardship. The review concludes that well-managed livestock systems can support sustainable development when ecological, nutritional, and socio-economic dimensions are assessed together. Its systems-based perspective highlights the need to evaluate livestock production through both emission intensity and multifunctionality, especially across different production contexts.

Policies and agricultural development strategies should adopt context-appropriate and interdisciplinary approaches that improve livestock productivity while promoting nutrition-sensitive interventions, equitable food distribution, and better management practices. Policy efforts should not focus only on reducing the environmental impacts of livestock production but should also optimize the relationship among environmental sustainability, food security, public health, and rural development, as emphasized in the article reviewed by Varijakshapanicker et al. (2019).

The review is limited by the nature of the evidence examined, as much of the empirical literature relied on observational studies, making it difficult to establish causality between animal-source food consumption, nutrition outcomes, and environmental impacts. Some reviewed studies were also context-specific, particularly in low- and middle-income countries, which may limit broader applicability. In addition, the absence of a strict systematic review protocol, clear inclusion and exclusion criteria, and formal bias assessment reduced the consistency and reliability of the conclusions.

Compliance with ethical standards

The authors declare that the study complied with applicable institutional and ethical standards for academic research. Since the paper is an article review and did not involve direct human respondents, issues on voluntary participation, informed consent, and confidentiality were not applicable. All reviewed sources were properly acknowledged, no conflict of interest was declared, and the authors take full responsibility for the originality, accuracy, and integrity of the manuscript, including matters related to citation, copyright, and authorship.

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