**A Holistic Impact of Nutrition-Led Extension of Given Agri-Livestock Systems**

**Abstract**

Malnutrition is considered one of the most important threats globally and brings about undesirable impacts both on the health of humans and economic potential. In recent years, the emergency reduction of malnutrition has become utmost policy priority, which is realized to be accomplished through nutrition-led extension, leading to its evolution in trends. The purpose of this study is to investigate the integration of nutrition and extension advisory services (EAS) that encompasses all activities/interventions/strategies aimed at providing information and services on nutrition sensitive farming needed by farmers and other stakeholders in rural settings, which assist them in developing their own technical, organisational, and management skills and practices, so as to improve their livelihoods and well-being achieving desirable food security satisfying both hunger and hidden hunger . The study also focused on realising the importance of agriculture, livestock, and allied sectors as the crucial component in nutrition-led extension and determines the various challenges encountered, which need to be attained . The findings associated with systematic literature review concerning nutrition led extension revealed the major barriers like inadequate skills in training professionals, lack of funding, negligible pluralistic approaches, negligible role of women, and other minor barriers . There is an essentialness by government, research institutions, and other stakeholders in overviewing the existing schemes and policies and to work in overcoming the lacunae through employing different approaches to varied situations, which can be understood through analysing case studies discussed.

**Key words:** Extension advisory services, hidden hunger, interventions, malnutrition, pluralistic approaches.

1. **Introduction**

Nutrition-led extension describes the integration and incorporation of nutrition education and communication within agricultural extension services to enhance food security and dietary outcomes (Keding et. al., 2021). Nutrition-led extension refers to a methodological approach within agricultural and rural extension services that combines nutritional objectives and practices into agricultural development and advisory systems. It aims to address food security, dietary diversity, and improved nutritional outcomes by combining agricultural productivity with nutritional awareness and interventions (Pandi, 2014). It is a participatory process where extension agents, farmers, and stakeholders collaborate to integrate nutrition education and the promotion of nutrient-rich crops, livestock, and practices into conventional extension services (Hawkes & Fanzo, 2017). The approach ensures the farmers to adopt practices that not only improve yields but also enhance the availability and accessibility of nutrient-dense foods, assisting to better health and well-being (Baye, 2017).

This approach is also closely aligned with the United Nations' Sustainable Development Goals (SDGs). As a result, NLE emerged as a central strategy and key tool for achieving Sustainable Development Goals (UN 2015).

The objectives that have been framed give a broad understanding of the concept, which includes,

* To understand the concept of nutrition-led extension, essential in addressing the global concern, i.e., malnutrition.
* To determine the strategies and interventions that can impact the rural communities and other beneficiaries towards a positive growth.
* To analyze the integration of the key concepts associated with nutrition-led extension.
* To assess the challenges faced by extension advisory services (EAS) in relation to nutrition-led extension and identify opportunities for strengthening these services.
1. **History in relation to the evolution of Nutrition -Led Extension**

The history of Nutrition-Led Extension (NLE) is closely and strongly tied to the evolution of agricultural extension services and the realization of the role of agriculture and allied sciences in addressing the issues of malnutrition and public health challenges (Rivas et al., 2012). Early agricultural practices and extension efforts focused primarily with their goal on increasing food production to address hunger. The majority of nutrition-related interventions were components of public health campaigns rather than agricultural concerned programmes. Agricultural extension programs were established in many countries, but their main goals were concentrated on increasing yields and improving farming techniques.

With the attainment of the Green Revolution (1940s–1960s), significant advances were achieved in agricultural productivity, especially on staple crops like wheat, rice, and maize. While food security has improved, this period highlighted the concept of "hidden hunger," where calorie adequacy and sufficiency have masked micronutrient deficiencies. Global initiatives such as the International Conference on Nutrition (1992) promoted for agriculture and livestock roles in addressing malnutrition. The concept of "nutrition-sensitive agriculture and livestock" started to take shape, laying the groundwork for NLE. A renewed emphasis on incorporating nutrition into agricultural extension resulted from growing understanding of the double burden of malnutrition, which includes both undernutrition and overnutrition (Kadiyala et al., 2014).

Governments, research institutions, and development agencies began incorporating nutrition goals into agricultural policies and extension services. The Food and Agriculture Organization (FAO), GFRAS, FAO, and other global agencies promoted suitable frameworks for nutrition-sensitive agriculture and extension services, bringing formalization to the concept. In the present decade, advances in technology, such as mobile-based advisory services, made it easier to deliver NLE to remote communities (Picchioni et al., 2017).

Realizing the advantage of combined efforts of public health campaigns on nutrition and its integration with EAS (extension advisory services being the vital component of agriculture and allied sciences development) has been marked generating the concept of Nutrition Led Extension (NLE). The mission of NLE can be best achieved with agriculture, livestock, and allied sciences, raising the concept of nutrition-sensitive agriculture, nutrition-sensitive livestock, etc. (Scholl et al.., 2011). Today, NLE represents the result of decades of efforts and attempts to bridge the gap between agriculture and nutrition, enhancing that improving food production is not enough—what people cultivate and grow must also nourish them (Scholl et al., 2011)

1. **ABCD (Advantages, Benefits, Challenges, Disadvantages) analysis of NLE**
	1. **Advantages and Benefits of Nutrition-Led Extension**

Enhanced nutritional practices stimulate the production and consumption of foods rich in essential nutrients, thereby mitigating malnutrition and deficiencies in micronutrients while concurrently improving food security through diversified agricultural systems. The alignment of agricultural practices with public health concerns facilitates an improvement in dietary quality and empowers the women by strengthening their role in household nutrition. An increase in awareness and educational initiatives enables farmers to adopt balanced dietary practices and implement appropriate food storage methods, while economic advantages are realized through the marketing of high-value, nutrient-rich crops and livestock. The phenomenon of hidden hunger is mitigated through the cultivation of biofortified crops, such as sweet potatoes enriched with vitamin A, and the resilience to climate change is enhanced through the promotion of sustainable and adaptive agricultural methodologies. Community empowerment cultivates collaborative efforts among the sectors of agriculture, health, and education, resulting in comprehensive rural development. The encouragement of behavioral modifications toward healthier dietary habits fosters improvements in long-term well-being, while sustainability initiatives advocate for organic farming practices and the cultivation of diverse, locally adapted crops. Ultimately, enhanced nutrition contributes to improved physical and cognitive functioning, thereby elevating farmers' productivity and overall quality of life (Arnold & Schreiber, 2012).

* 1. **Challenges and Disadvantages of Nutrition-Led Extension**

Nutrition-led extension programs pose several challenges. Knowledge and capacity gaps arise as extension agents may lack sufficient training in nutrition-sensitive practices. Limited resources like funding and infrastructure hinder effective implementation. Cultural barriers cause difficulty to change traditional dietary habits, while the complexity in integration poses varied challenges in coordinating agriculture, health, and education sectors. Resistance to change is another major concern, as farmers often prioritize cash crops over nutrient-rich ones. Additionally, these programs and approaches are time-intensive and often require sustained efforts to shift dietary habits. Lack of proper monitoring and evaluation studies make it difficult to measure program impact, and uneven benefits/unintended consequences may exclude vulnerable groups, like landless labourers, from reaping the advantages (Sharma et al., 2018).

1. **Implementation strategies with reference to NLE**
	1. **Strategies to adopt in nutrition-led extension through agriculture**

Effective strategies and approaches in Nutrition-Led Extension (NLE) improve nutrition outcomes through agriculture. Promoting nutrient-rich food production systems through crop diversification, integrated farming, and agroforestry practices increases dietary diversity. Capacity enhancement for extension personnel provides them with nutrition-sensitive insights and tools for efficient outreach initiatives. Community-centric methodologies, such as backyard gardens and demonstrations, empower households to implement better nutritional practices. encouraging animal-sourced foods (ASFs) contribute to the establishment of balanced diets, particularly for vulnerable populations. Behavior change communication (BCC) fosters awareness regarding dietary diversity, child nutrition, and food safety through the engagement of local leaders and media channels. Gender-responsive strategies acknowledge the pivotal roles of women in nutrition, thereby providing them with specialized training and resources. Market linkages facilitate farmers in marketing nutritious products while simultaneously enhancing local access to healthful foods. Biofortified crops, including iron-enriched beans and vitamin A-enhanced maize, effectively address micronutrient deficiencies. Multisectoral collaboration integrates agriculture, health, and education to formulate a comprehensive nutrition strategy. Monitoring and evaluation mechanisms assess progress through dietary diversity indices and malnutrition prevalence rates. The integration of technology through mobile applications and digital content broadens outreach capabilities. Food safety education mitigates contamination and nutrient loss, while climate resilience strategies ensure the sustainable production of nutrient-rich foods. (Grace et al., 2018).

* 1. **Strategies to adopt in nutrition-led extension through livestock**

Adopting Nutrition-Led Extension (NLE) strategies through livestock entails leveraging the nutritional benefits and economic potential of animal-based food systems to improve household nutrition and food security.

Promoting Animal-Sourced Food (ASF) consumption necessitates educating the communities on the nutritional advantages of dairy, eggs, meat, and fish, particularly for vulnerable populations. Households are encouraged to achieve a balance between ASF consumption with sales to ensure adequate family nutrition. Supporting Small-Scale Livestock Farming through the rearing of backyard poultry, goats, sheep and engaging in aquaculture offers accessible and economically feasible protein sources, thereby benefitting resource-limited farmers while simultaneously enhancing household nutrition (Sharma et al., 2018).

Breed selection for nutrition and productivity advocates for the promotion of dual-purpose and climate-resilient breeds for optimal milk and meat production, which are supported by schemes like the National Livestock Mission, Rashtriya Gokul Mission, and National Dairy Plan. Enhancing Livestock Feeding and Health involves training farmers to grow nutrient-rich fodder, utilizing feed supplements to elevate ASF quality, and implementing disease management practices such as vaccination and deworming to safeguard livestock health and food safety.

Enhancing Value Addition and Gender inclusion within livestock management enhances ASF availability and economic benefits. Training and capacity building of farmers in milk processing, egg preservation, and meat drying extends product shelf life and market potential. Empowering women within small-scale livestock enterprises strengthens household nutrition and augments income. Enhancing ASF quality and education involves the provision of biofortified feed for nutrient-enriched livestock products and training extension workers to educate farmers on ASF nutrition and cooking techniques. Community-based demonstration farms serve to showcase best practices, while the integration of livestock and crop systems promotes sustainability through the utilization of manure and fodder cultivation.

Strengthening market access and behavioral change guarantees that farmers can effectively sell surplus ASFs and benefit from value addition like cheese and yogurt production. Campaigns aimed at altering behavior underscore the importance of ASF consumption, safe handling practices, and the prevention of zoonotic diseases. Improving Animal Health and Sustainable Practices involves timely veterinary support, vaccination, and backyard livestock systems for vulnerable households. Linking livestock production to school feeding programs supports child nutrition while stimulating local economies. Climate-Smart Livestock and monitoring prioritize the promotion of resilient breeds and sustainable management, reducing environmental impact. Regular monitoring of ASF consumption, dietary diversity, and malnutrition rates helps refine interventions for better nutrition outcomes (Keding etal., 2021).

Nutrition-Led Extension in Livestock aims to synchronize agricultural development with improved human nutrition and health by enhancing livestock nutrition. This approach will boost milk, meat, and egg production, improving food security for both farmers and consumers. Animal Feed Management concentrates on educating farmers regarding species-specific nutritional needs, promoting the utilization of locally available feed resources and supplements. Forage and Grazing Management ensures consistent access to high-quality fodder, while nutritional supplementation addresses vitamin, mineral, and protein deficiencies to improve livestock productivity (Kadiyala etal., 2014).

Training and Capacity Building provide and equip the farmers with skills in feeding strategies, ration formulation, and sustainable feed production. Sustainable practices like crop-livestock integration, fodder banks, and hydroponic fodder will balance livestock nutrition with environmental conservation. Advanced nutrition techniques include feed additives such as probiotics, enzymes, and ionophores to improve gut health and feed efficiency while reducing methane emissions. Biofortified and mineral-rich feeds, precision feeding technologies, and digestibility-enhancing methods like chopping, grinding, urea treatment, and silage fermentation further optimize livestock nutrition, leading to healthier animals and higher productivity (Baye, 2021).

1. **Interventions made by government and institutions in progress of NLE**

Often, the different government schemes work to ensure food security, ignoring its nutritional aspects. None of such projects have a significant impact on the nutritional status of farm families, whose nutritional status is already low. On the other hand, growing food prices reduce their protein consumption and micronutrients from fresh foods, pulses, eggs, milk, vegetables, and fruits. Hence, a pattern of changes incorporated suitably towards achieving the desired outcomes associated with nutrition led extension through updating of the schemes (Holla and Ittyerah, 2018).

* 1. **Potential pathways/approaches in concern to effective reach of NLE**

**Food Systems Approach and Extension Strategies for Nutrition**: It is essential to be concerned about unsafe foods and poor diets. This comprehensive framework covers the aspects of production, storage, transport, processing, and consumption, addressing trade, subsidies, price fluctuations, technological advancements, food safety, and waste management (Dixit, 2023).

**The Eat Right India Movement** initiated by FSSAI focuses mainly on three pillars: **Eat Safe**: Ensuring proper hygiene, reducing food adulteration, and controlling potential hazards in food production. **Eat Healthy**: Promoting diet diversity and reducing unhealthy foods. **Eat Sustainable**: Encouraging local, seasonal foods, reducing food waste, and promoting sustainable packaging practices (Dixit, 2023).

**The whole of Government Approach** is essential for achieving a nutrition-smart India, requiring coordinated efforts between multiple ministries, strong leadership, and multi-stakeholder collaboration (AESA, 2020).

* 1. **Extension Approaches for Nutrition Improvement**

**Farmer-led Extension**: Self-Help Groups (SHGs), Farmer Interest Groups (FIGs), and cooperatives empower farmers in decision-making and technology adoption of nutri-sensitive practices (Garret & Natalicchio, 2011).

**Women’s Empowerment & Education**: As rural women play a prominent role in agriculture, improving their access to resources and decision-making enhances household nutrition (Garret & Natalicchio, 2011).

**Use of ICT**: Digital tools can disseminate nutritional education, promote diversified diets, and support smart choices (Garret & Natalicchio, 2011).

**Farming Systems Approach**: Encouraging integrated farming (livestock, poultry, fishery, and horticulture) increases income, resilience, sustainability and dietary diversity (Garret & Natalicchio, 2011).

**Collective Approach**: SHGs and cooperatives enhance small farmers’ market orientation, reduce associated risks, and improve nutritional outcomes (Garret & Natalicchio, 2011).

The extension system must extend beyond technology dissemination in promoting nutrition-sensitive agriculture, encouraging social and behavioral change. Scaling up gender-responsive and nutrition-enhancing advisory services is crucial, with youth and women acting as change agents in rural nutrition transformation (AESA, 2020).

* 1. **ICAR Initiatives**

The Indian Council of Agricultural Research has been effortlessly promoting the concept of nutrition-led extension through a systematically planned program called ‘Nutri-sensitive Agricultural Resources and Innovation (NARI). ’ To promote Nutri-sensitive agriculture, it is of prime importance to raise awareness among farm women and youth about Nutri-gardens, Nutri-thalis, and the cultivation of biofortified crops. Key activities include:

* Training Anganwadi workers (mostly women) on establishing Nutri-gardens, growing biofortified crops and millets, and preparing Nutri-thali recipes.
* Krishi Vigyan Kendras (KVKs) have developed location-specific Nutri-garden models to ensure access to healthy, diversified diets (Vijayakhader, 2017).

These efforts collectively contribute to improving access to nutritious, locally grown foods, especially in resource-limited areas.

* 1. **Schemes**

Several governmental initiatives are currently operational, designed to mitigate the challenges associated with nutritional insecurity or enhance the nutritional well-being of women and children. These initiatives possess the potential for integration with extension education.

**The Half Acre Model of Telangana** is intended to assist female farmers in fulfilling their nutritional needs (Kadiyala et al., 2014).

**The Rajiv Gandhi Scheme for Empowerment of Adolescent Girls** is dedicated to enhancing the nutritional and health outcomes of girls aged 11 to 18 through comprehensive education in life skills, health, and nutrition.

**Indira Gandhi Matritva Sahyog Yojana** seeks to foster improved healthcare practices for young women throughout the stages of pregnancy, delivery, and lactation.

**The National Iodine Deficiency Disorder Control Programme** offers a framework for coordinated nutritional interventions via extension efforts.

**Ksheera Bhagya Yojana** Government of Karnataka has implemented the "which entails providing 150 ml of hot milk to schoolchildren for three days per week. The principal aims include the enhancement of nutritional and health status while preventing malnutrition.

The Srushti scheme is designed to enhance the supplementary nutritional health of children as well as pregnant and lactating mothers. It represents one of several initiatives launched by the state government to combat malnutrition (Keding et al., 2021).

Other programmes like POSHAN Abhiyan, Integrated Child Development Scheme, Mid-day meal scheme, supplementary nutrition programme, and Balwadi Nutrition programme are many of them promoting the concept of nutrition-led extension (Kadiyala et al., 2014).

The livestock-associated schemes that support achieving NLE efficiently include **Regional Fodder Development Programs** encourage region-specific fodder production, whereas the **National Livestock Mission** (NLM) supports feed processing, silage units, and fodder cultivation. Hydroponic fodder technology and fodder production facilities are funded by the **Rashtriya Krishi Vikas Yojana** (RKVY). Credit is available for the purchase of high-quality feed and supplements through the **Pashu Kisan Credit Card Scheme**. While **FAO Livestock Development Projects** encourage the use of agro-industrial byproducts and crop residue treatment for feed augmentation, state-level **livestock feed subsidy schemes** guarantee reasonably priced feed during shortages.

**NABARD’s Dairy Entrepreneurship Development Scheme (DEDS)** provides subsidies for silage units and feed storage. Furthermore, **Smallholder Livestock Feed Programs** by NGOs encourage community-based feed production, and the **Sub-Mission on Fodder and Feed Development** addresses fodder shortages through innovative feeding solutions and financial aid and assists in fodder block-making units (Vijayakhader, 2017).

All these programmes, policies, and approaches effectively work in facilitating the beneficiaries to enhance the productivity of livestock through balanced feed in one dimension and improved livelihood of farmers in other dimensions through nutrient feed intake as well as economic conditions **(**[**https://dahd.gov.in/schemes-programmes**](https://dahd.gov.in/schemes-programmes)**).**

1. **Conclusion**
* Nutrition-led extension serves as a multifaceted strategy that addresses various SDGs by linking agriculture with health, education, and sustainable development. Its holistic and comprehensive focus fosters resilient communities, healthier populations, and a sustainable future (Picchioni et al., 2017).
* Agriculture, Livestock, and allied sciences function as a powerful tool in Nutrition-Led Extension, offering nutrient-dense foods, income, and sustainable farming options. By adopting these strategies, NLE can maximize its role in addressing malnutrition and improving rural livelihoods (Dal, 2025).
* To implement Nutrition-Led Extension effectively, suitable strategies must be incorporated and integrated with broader development goals (Baye, 2017).
* By promoting dietary diversity, nutrition education, and sustainable practices, NLE guarantees that agricultural productivity is achieved in addition to improved health and overall well-being (Wiafe-Amoako, 2016).
* Addressing and focusing on animal nutrition achieves the symbiotic relationship between animal health, productivity, and human nutrition, establishing a sustainable path for rural development (Keding et. al., 2021).

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**General Comments**

**The study emphasized nutrition-driven extensions but did not specify the location of the study. Additionally, it was unclear whether the document was a report or a case study. The references need to be revised in the manuscript. It would be beneficial for the authors to address these issues in the study.**