



Bridging the Gap: Transforming Food Systems Through Agricultural Extension: A Review

J.R. Shalini¹, G.S. Sreedaya², R. Shanmugabhavatharani³

10.18805/ag.R-2787

ABSTRACT

This article scrutinizes the immediate need for transformation within the global food system to address escalating demands and sustainability challenges. It underscores the critical role of agricultural extension services in bridging the gap between innovative practices and their practical implementation, thereby empowering farmers with the knowledge and resources needed to adopt sustainable practices. By facilitating access to new technologies and fostering connections among farmers, extension services can optimize resource use, reduce food waste and enhance food security. Ultimately, the article claims that effective extension interventions are indispensable for achieving the Sustainable Development Goals (SDGs) by 2030 and creating a more resilient and equitable food system in the future.

Key words: Extension services, Resilient and equitable food system, Sustainable development goals, Sustainable practices, Transformation in food system.

Important considerations are currently intimidating the sustainability and resilience of the global food system. It is becoming more and more clear that current agricultural methods and infrastructures are insufficient to supply the growing demand for food, which is being driven by population growth and shifting dietary preferences. Resource depletion, climate change and unequal access to technology intensify the challenge, highlighting the urgent need for novel approaches.

In this context, agricultural extension services emerge as a noteworthy mechanism for facilitating the necessary modifications in food systems. By bridging the gap between innovative practices and their practical application, extension services can empower farmers and stakeholders with the knowledge, tools and resources needed to adopt sustainable practices (FAO, 2018). This article exemplifies how extension can play a pivotal role in transforming our food systems to ensure food security and sustainability, ultimately contributing to the achievement of the Sustainable Development Goals (SDGs) by 2030 (Prajal *et al.*, 2021). Through targeted interventions and the promotion of new technologies, extension services can support in connecting farmers to modern agricultural innovations, enhance resource use efficiency and mitigate the consequences of climate change, paving the way for a more resilient and equitable food system.

Food system

Food systems encompass all the people, institutions, places and activities that play a role in growing, processing, transporting, selling, marketing and, ultimately, eating food (Anonymous, 2024). Food systems have a profound effect on diets by influencing the types of foods generated, the foods that are economically and physically obtainable and the dietary preferences of individuals.

¹Department of Agricultural Extension and Education, College of Agriculture, Vellayani-695 522, Kerala, India.

²Centre for Agricultural Innovations and Transfer of Technology, College of Agriculture, Kerala Agricultural University, ADE(SZ), Vellayani-695 522, Kerala, India.

³Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.

Corresponding Author: G.S. Sreedaya, Centre for Agricultural Innovations and Transfer of Technology, College of Agriculture, Kerala Agricultural University, ADE(SZ), Vellayani- 695 522, Kerala, India. Email: jarashasha@gmail.com

How to cite this article: Shalini, J.R., Sreedaya, G.S. and Shanmugabhavatharani, R. (2026). Bridging the Gap: Transforming Food Systems through Agricultural Extension: A Review. *Agricultural Reviews*. **47(4)**: 626-630. doi: 10.18805/ag.R-2787.

Submitted: 15-02-2025 **Accepted:** 21-08-2025 **Online:** 20-11-2025

Challenges of global food system

The global food system is projected to experience increasing challenges over the years due to rising population and per capita consumption. Rapid population growth magnifies the effects of climate change by depleting resources and increasing exposure to climate-related risks, especially in urban areas with limited resources (Mathew *et al.*, 2023). Growing food demand and competition for resources like land, water and energy that impact food availability are two problems faced by global food systems. Resilience in global food systems is more important than ever in light of climate change and unanticipated shocks like a worldwide epidemic. Global food production and related trade have grown steadily since the 1950s, when food systems became more interconnected. This expansion has been fuelled by improvements in communications

and transportation, as well as the removal of trade restrictions and agricultural tariffs. However, two major issues embrace the global food system's efficacy were nutrition and waste (Agrawal, 2021).

Food wastage happens at each level of the food chain. Harvesting, transportation, storage and processing all play a part to the loss of around 13.8% of food in supply chains. However, it is difficult to assess how pricing strategy can minimise food waste due to a lack of scientific understanding and study on the price elasticity of food waste. The resources, land and energy required to produce food are also wasted. From 2007 to 2016, forestry, agriculture and other land uses counted for over 23% of all human induced greenhouse gas emissions. In addition to farming and raising cattle, agriculture also contributes to emissions by clearing land for farming. Over, two billion people are affected by starvation wherein people lack key micronutrients such as iron, zinc, vitamin A and iodine. Apart from nutrient deficiency, approximately two billion people are obese and affected by long-term conditions include cardiovascular disease and type 2 diabetes.

In digest, the world's food system is unable to meet the population's evolving and growing needs. Social-cultural interactions, shifting dietary patterns, rising wealth and the wealth gap, limited resources, the difficulties of unequal accessibility and the demands of the underprivileged who spend the largest percentage of their income on food are all factors that need to be taken into consideration when upgrading the system. Food demand and supply chains must be lined up across different geographies and at different scales of space and time in order to feed the world's population, which is expected to reach 10 billion by 2050. Developing sustainable, equitable and healthful food systems that provide food and nourishment is closely related to the future of global food systems.

Transformation through extension

After reviewing a number of research, we reached the conclusion that the current food system needs to be transformed in order to meet the growing demands of the future and meet the Sustainable Development Goals (SDGs) by 2030. Given the current situation, extension intervention can be utilised to help bring about the change. To establish a sustainable food security strategy, the integration of information and communication technologies (ICTs) in agriculture is essential (Patel *et al.*, 2024). Market information extension might benefit farmers and farms by providing them with opportunities and access to new technologies and innovations, as many of them are unconnected or ignorant of these developments. Extension services play a critical role in bridging the gap between novel methods and their practical implementation in the transformation of food systems (Kristin *et al.*, 2010). By delivering up-to-date information, training and support, extension services enable farmers and stakeholders to adopt sustainable practices, optimize resource use and reduce food wastage. This guidance is essential for

adapting to climate change and ensuring long-term food security, thus facilitating a more resilient and efficient food system.

A study by Khan *et al.* (2021) also suggested that there is a need for technological intervention in the existing food system to arrive at transformed sustainable food system. To have technological intervention there is a need for technology innovation which could be transferred. In this aspect extension will play a significant role in transformation of food system.

Key roles of extension in achieving food security

First and foremost, technology transfer for food crops is a important task that needs to be carried out in order to attain and preserve national food security. Extension agents can be crucial in providing technical advice to all kinds of farmers early in the development process, before input providers are well-established. The public sector can continue to provide "objective" information on the particular technical solutions being supported by various input suppliers, but as input supply corporations grow, they will assume greater responsibility for this technology transfer function.

It is typical for staple food prices to progressively drop once nations attain national food security, reflecting the relative supply and demand for these goods. Small-scale farming households are facing a challenge as the cost of staple foods continues to drop. Due to their limited land base, they are unable to increase production and as their income declines, it becomes more challenging for them to maintain their productivity levels and buy inputs. To boost farm household income, they must so look for alternative methods and/or options. There must now be a "paradigm shift" in which public extension devotes more of its attention and resources to enhancing rural livelihood, the second national goal (Kristin *et al.*, 2010). Increasing farm earnings is a crucial component of this plan. The emphasis must change to the intensification and/or diversity of farming systems in order to achieve this. However, the alternatives available to various farm households for diversifying their agricultural systems will be directly impacted by the relative availability of land, labour, capital and local agro-ecological variables. Access to markets, including transportation, roads in all weather conditions and the distance to various local, regional, national and even international markets, is another important consideration. All of these elements, including access to the technologies available for these various companies, will, in short, decide whether crops, animals and/or other products may be effectively cultivated and marketed in each community, sub-district and district within a country. But in order to accomplish this, extension needs to start moving more of its focus, resources and expertise.

The necessity of organising interested farmers into producer groups for various high-value agricultural and livestock products is a third goal that is closely tied to the diversification of farming systems. This will allow them to

have greater access to markets and inputs for their businesses. These farmer organisations are better able to communicate their requirements to extension and other agricultural organisations, including research, once they are established and have gained experience. Furthermore, once women farmers start collaborating in groups, they start exchanging knowledge about enhancing family health, hygiene and nutrition, which can further enhance rural livelihoods, particularly for children. At last, for a country to maintain national food security over the long-term, it is critical that farmers individually and collectively know how to maintain their soil fertility, stop land degradation and to make efficient use of increasingly scarce water resources, all these factors will be addressed through extension intervention. These are “public good” issues, which the private sector will generally not address; therefore, the public extension must allocate more time, attention and expertise to these growing natural resource management (NRM) problems.

Role of extension workers

Extension workers play a significant role in enhancing and fortifying agriculture by acting as motivator, facilitator, educator and communicator (Wulandari *et al.*, 2021). Effective extension services bridge the novel discoveries with the changes in the farmer's field (Gulsia, 2024). The extension workers have traditionally been disseminators of information on cropping techniques, high yielding varieties, price discovery, optimal input use and managerial competence.

As a motivator

All farmer organisations, both in rural and urban regions, vitally need the assistance of an extension agent as a motivator. Extension agents need to be able to inspire farmers to consistently use resources efficiently. It is evident that a substantial amount of extension workers are involved in providing passion and motivation for the utilisation of resources, as agricultural instructors encourage group members to attain the outcomes that their groups desire.

As a facilitator

The extension worker's role as a facilitator is to assist the community in order to encourage its participation in farming activities. This includes paying attention to and comprehending the community's desires, laying down support and maintaining facilities for the community.

As an educator

The extension furnishes farmers or farmer groups information about farming because the agricultural instructor's mission is to educate farmers. With the extension, it is envisioned that those who are unwilling to be willing would alter their attitude and those who are unaware will change their knowledge. In order to inform farmer groups and the community on recent developments in the agricultural industry, the teacher will present material pertaining to agriculture.

As a communicator

Farmers also require the extension worker to be a strong communicator since they will be able to grasp the instructor's instructions more readily. Both individually and in groups, extension workers plan the communication process in accordance with the program being executed. To ensure that there are no misunderstandings, the instructor should employ simple language when delivering the topic.

Role of EAS in revamping the food system

The recent report released by AESA on revamping the food system highlighted the role of extension advisory services as follows:

- EAS can be used to survey the locally accessible woodland edibles and uncultivated foods.
- Can include courses on “uncultivated foods and forest foods” in the curriculum.
- Initiatives for capacity building can be organized through EEIs, SAMETIs dealing with nutrition.
- NGO's can be tied up in developing materials on these aspects.

Recent trends in agricultural extension

India's agricultural extension services have undergone a transformation by virtue of the use of digital and mobile technology, which has enhanced the speed, accuracy and reach of information dissemination. These technologies have become essential resources for narrowing the empirical gap between research and farming methods, giving farmers more tools to increase agricultural sustainability and production (Manohar *et al.*, 2024). Mobile applications and SMS based services have become especially transforming in India, a country with vast mobile penetration. Agri-tech startups and government initiatives have introduced several mobile apps that provide services ranging from weather forecasts and crop recommendations to market prices and agricultural advisories. For example, the ‘Kisan Suvidha’ app, brought to use by the Ministry of Agriculture and Farmers Welfare, offers farmers comprehensive resources including weather updates, market prices, plant protection and dealer networks. SMS services have also evinced effective in reaching out to farmers with critical updates. The ‘Kisan SMS Service’ launched by the Indian government sends out millions of texts to registered farmers, providing up-to date information about weather and pest attacks, which helps in reducing crop losses and enhancing productivity. Remote sensing and Geographic Information Systems (GIS) are being progressively employed to improve the precision of farming practices. These technologies concede for the monitoring of crop health, soil conditions and water resources, enabling targeted interventions. The Indian Space Research Organization (ISRO) has been vital in deploying satellite imagery for agricultural purposes, assisting in crop area estimation and condition assessment under the

FASAL project (Forecasting Agricultural output using Space, Agrometeorology and Land-based observations).

Impact of emerging trends on global food system

Emerging trends in agricultural extension have greatly enhanced agricultural productivity around the world (Manohar *et al.*, 2024). Innovations such as precision agriculture, digital and mobile technologies and improved crop varieties have allowed farmers to expand yields while reducing waste and inefficiency. Farmers are now able to gather and share data in real time using mobile technologies, which helps them make better decisions about planting, controlling pests and harvesting. Research conducted in Kenya and India has shown that by promptly disseminating information on weather forecasts and ideal farming techniques, mobile advisory services can result in output improvements of 10-30%. Food security improves as a direct result of higher agricultural productivity. Emerging trends are helping nations produce more food by increasing the productivity and efficiency of agricultural systems, which lowers reliance on imports and stabilises domestic food supplies. Local food security has improved, especially in areas that have adopted farmer field schools and community-supported agricultural programs. These participatory approaches empower farmers by improving their knowledge base and skills, which translates into better crop management and higher productivity, ultimately securing local food systems. In order to manage agricultural resources more efficiently and guarantee that food production can be maintained throughout time, technologies such as GIS and remote sensing have become essential. To maintain agricultural productivity and food security, for example, remote sensing technologies are used to forecast yields, monitor crop health and effectively manage water resources. Rural communities' economic resilience is greatly boosted by new developments in agricultural extension. These trends have improved economic activity in rural communities, decreased farming risks and given farmers new sources of income by adopting leading-edge agricultural practices and technologies. By engaging these often underutilized segments of the rural population, agricultural programs help build a more robust economic foundation, reducing poverty and enhancing economic resilience. Public private partnerships have also played a crucial role in bringing investment and infrastructure development to rural areas, further bolstering economic resilience. These partnerships often lead to improved agricultural practices, better market access and increased capacity building, which contribute to sustainable economic development in these regions. One of the most significant impacts of emerging trends in agricultural extension is the promotion of environmental sustainability. Sustainable and organic farming techniques, which are increasingly being adopted worldwide, help preserve biodiversity, improve soil health and reduce the ecological footprint of farming. Notwithstanding the benefits,

modern agricultural extension techniques come with a number of drawbacks and restrictions. For smallholder and resource-poor farmers, the high cost of technology and the requirement for specialised expertise can be major obstacles. Furthermore, there is frequently a disconnect between the creation of information and its actual use, which may reduce the efficacy of novel extension strategies. Although digital and mobile technologies have the potential to revolutionise agricultural extension, their widespread adoption is still hampered by problems including digital literacy, connectivity in rural locations and the dependability of ICT infrastructure. In addition, the one-size-fits-all approach of large-scale extension programs might not be sufficient to address the diverse needs and conditions of different regions and farming communities.

Role of digitalization for - A sustainable agri-food system

Digital technologies contribute to increased efficiency, transparency and trust in the agri-food industry (Onwude, 2023). Through the use of data analytics, digital models, automation, sensors, simulations and other technical tools, they enable process monitoring, cost reduction and an enhanced customer experience. Furthermore, by facilitating real-time data exchange, encouraging stakeholder interaction, forecasting food quality, increasing energy efficiency, reducing food waste and optimising resource management, digitisation successfully addresses sustainability issues in food systems. Digital technologies have become ubiquitous in increasing productivity and improving decision-making processes across all stages of food production, from promoting genetic enhancements to optimising farm management and transportation networks while satisfying consumer needs.

In the horticulture value chain, lowering food loss and increasing energy efficiency are two critical areas where digital solutions are significant. Stakeholders can address the problems of climate adaptation and mitigation by minimising waste at different stages of the supply chain through the integration of software-driven solutions. For example, real-time crop monitoring during storage and transportation can be made possible by wireless sensors and Internet of Things devices, allowing for prompt interventions to stop spoiling or loss in the postharvest supply chain. Food producers can also enhance process performance in postharvest processes including drying, cooling, fermentation, extraction and packing by utilising robotics, smart materials and AI-powered smartphone apps. This successfully lowers waste and energy consumption. Essentially, software and digital solutions promote energy efficiency, decrease food waste and function as catalysts for sustainable practices.

CONCLUSION

In conclusion, in order to handle the difficulties of a world that is changing quickly, it is not only necessary but also

urgently critical that we reform our food systems. This change is mostly due to agricultural extension services, which serve as an important conduit between farmers and modern farming methods. Extension services may dramatically increase resource efficiency, decrease food waste and strengthen food security by making innovative technology more accessible, improving knowledge exchange and encouraging cooperation among agricultural stakeholders. Prioritising successful extension interventions will be crucial to creating a resilient, sustainable and equitable food system that can adjust to the challenges of the future as we work to meet the Sustainable Development Goals by 2030. Putting money into extension is more than investing in the future of food security and the livelihoods of millions worldwide.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

- Anonymous. (2024). GAIN and The Columbia Climate School [on line]. Food Systems Dashboard. Available: <https://www.foodsystemsdashboard.org/information/about-food-systems> [10 Aug.2024].
- Agrawal, M. (2021). Future of food: Exploring challenges to global food systems [on line]. Available: <https://news.columbia.edu/2021/01/15/global-food-systems-challenges>. [7 Aug.2024].
- FAO [Food and Agriculture Organization]. (2018). Sustainable food systems-Concepts and framework [online]. Available: <https://openknowledge.fao.org/server/api/core/bitstreams/content>. [9 Aug.2024].
- Gulsia Oshin (2024). Agri-food systems amidst COVID-19: A review. *Agricultural Reviews*. **45(1)**: 109-114. doi: 10.18805/ag.R-2349.
- Khan, N., Ray, R.L., Kassem, H.S., Hussain, S., Zhang, S., Khayyam, M., Ihtisham, M. and Asongu, S.A. (2021). Potential role of technology innovation in transformation of sustainable food systems: A review. *Agric*. **11(10)**: 2-5.
- Kristin, D.E., Burton, S., David, A., Ayalew, M.D., Aaron, F., Jens, R., Chloe, L. and Elias, Z. (2010). In-depth assessment of the public agricultural extension system of Ethiopia and recommendations for improvement [on line]. Available: <https://ebrary.ifpri.org/digital/collection/p15738coll2/id/7610>. [10 Aug.2024].
- Manohar, K.N., Rajesh C.M., Jadhav, A., Anil K., Bhat, P.P., Prasad, R.P. and Raj, B.M.U. (2024). A review on emerging trends in agricultural extension and their impact on global food systems. *J. Exp. Agric. Int*. **46(7)**: 1173-1186.
- Mathew, R., Sarojini, S.G., Smitha, S. and Shaji, A.T. (2023). Urban agriculture: An approach towards creating sustainable smart cities: A review. *Agricultural Reviews*. **46(3)**: 349-358. doi: 10.18805/ag.R-2629.
- Onwude, D. (2023). What is the role of digitalisation for a sustainable agri-food system? [on line]. Available: <https://energybase.org/news/what-is-the-role-of-digitalisation-for-a-sustainable-agri-food-system>. [5 Aug.2024].
- Patel, M., Khodifad, P.B. and Chaudhary, M. (2024). Utilisation of artificial intelligence-related technology for agricultural extension services among extension professionals in India. *Bhartiya Krishi Anusandhan Patrika*. **39(3-4)**: 288-293. doi: 10.18805/BKAP695.
- Prajal, P., Tek, B.S. and Juergen, P.K. (2021). Why food systems transformation is crucial for achieving the SDGs. *Rural*. **21**: 10-12.
- Wulandari, R., Witjaksono, R. and Wati, R.I. (2021). The Role of Agricultural Extension Workers in Urban Agriculture Development during the Covid-19 Pandemic in Yogyakarta city, Indonesia. In: Proceedings of 1st International Conference on Sustainable Agricultural Socio-economics, Agribusiness and Rural Development (ICSASARD 2021), 22 September 2021, Department of Agricultural Socio-Economics, Faculty of Agriculture, Gadjah Mada University. pp. 20-30.