



A Comprehensive Review on Role of Agricultural Extension Services in the Sustainable Development of Global Agriculture

Abhijeet ^{a++}, Kanta Kumar Sahu ^{b++}, Raj Bardhan ^{c#},
Nikita Singh Chouhan ^{b++}, Devanshu Dixit ^{b++*},
Somdutt Tripathi ^{d++}, Anjali Pandey ^{e++} and Rizwan Ahmed ^{f++}

^a Department of Agricultural Extension, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh (208002), India.

^b Department of Agricultural Extension, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh (485334), India.

^c Department of Agricultural Extension Education, Bihar Agricultural University, Sabour, Bihar (813210), India.

^d Department of Agricultural Extension, Banda University of Agriculture and Technology, Banda, Uttar Pradesh (210001), India.

^e Department of Agricultural Extension, Rama University, Kanpur, Uttar Pradesh (209217), India.

^f Department of Agricultural Economics, Central Agricultural University, Imphal, Manipur (795004), India.

Authors' contributions

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⁺⁺ Ph.D. Scholar;

[#] M.Sc.;

*Corresponding author: E-mail: dixit02devanshu@gmail.com;

ABSTRACT

In an era where agriculture is facing unprecedented challenges, from climate change to increasing food demands, this paper aims to critically re-evaluate the current paradigms governing agricultural extension services. These services are instrumental in bridging the gap between agricultural research and practical farming, serving as a catalyst for the dissemination of knowledge, technology, and best practices among farmers. Recognizing their pivotal role in agricultural transformation, this paper offers a comprehensive evaluation of the role and effectiveness of agricultural extension services, advocating for a multidimensional assessment framework that incorporates environmental, social, and economic indicators. Traditionally, the success of agricultural extension services has been measured primarily through yield improvements or technological adoptions. This study argues that such unidimensional assessments are inadequate for capturing the complex, interrelated challenges and opportunities in contemporary agriculture. On the environmental front, factors like soil health, water quality, and biodiversity are shown to be foundational for sustainable agricultural practices and have immediate consequences for crop yield and quality. Social considerations, including farmers' well-being, community cohesion, and equitable access to resources, are equally crucial. These extend the scope of agricultural extension services beyond the mere dissemination of technical knowledge to encompass broader social objectives, such as community development and social equity. Economically, the study underscores the importance of indicators like profitability, yield per hectare, and value-added products, emphasizing that these are both immediate and long-term measures of the success of agricultural practices. By combining these diverse but interrelated metrics, the paper presents a more holistic view of the effectiveness of agricultural extension services. The research concludes by recommending policy adjustments and methodological shifts to incorporate this integrated assessment framework, aiming to guide the transition toward a more sustainable, equitable, and economically viable agricultural landscape.

Keywords: Agricultural extension; assessment framework; extension services; multidimensional; sustainability.

1. INTRODUCTION

Agricultural extension services have a long and varied history, dating back to as early as the late 19th century [1]. The formalization of agricultural extension services in the United States, for example, came with the passage of the Smith-Lever Act of 1914. Subsequently, countries around the globe have adapted this model to their unique economic and cultural contexts [2]. Over time, these services have transformed from being mere agents of technology transfer to facilitators of broader development initiatives. The concept of sustainable development in agriculture aims at achieving food security while preserving the environment [3]. It has gained importance as the global population is projected to reach 9 billion by 2050, leading to increased stress on resources. The role of agricultural extension services in facilitating sustainable practices is critical [4]. This review paper will provide a broad examination of agricultural extension services globally, focusing on both developed and developing nations. It will cover the evolution of traditional extension models and the impact of technological advancements [5].

The primary objective is to comprehensively analyze the role of agricultural extension services in sustainable development. The paper aims to examine the historical context, evaluate current status, identify challenges, and forecast future trends. The review is confined to articles published between 1990 and 2023, and only papers available in English were included. The document types considered for inclusion range from reviews, original research articles to policy briefs.

2. LITERATURE REVIEW

Agricultural extension services can be defined as the practice of transferring agricultural technology and knowledge to farmers through diverse educational methods [6]. The ultimate goal of extension services is to improve farmers' practices, increase productivity, and foster sustainable development [7]. It extends beyond technology transfer to include facets like facilitating market access, disseminating knowledge on climate change, and advocating for gender equality [8]. The concept has been further refined through the years. Some scholars

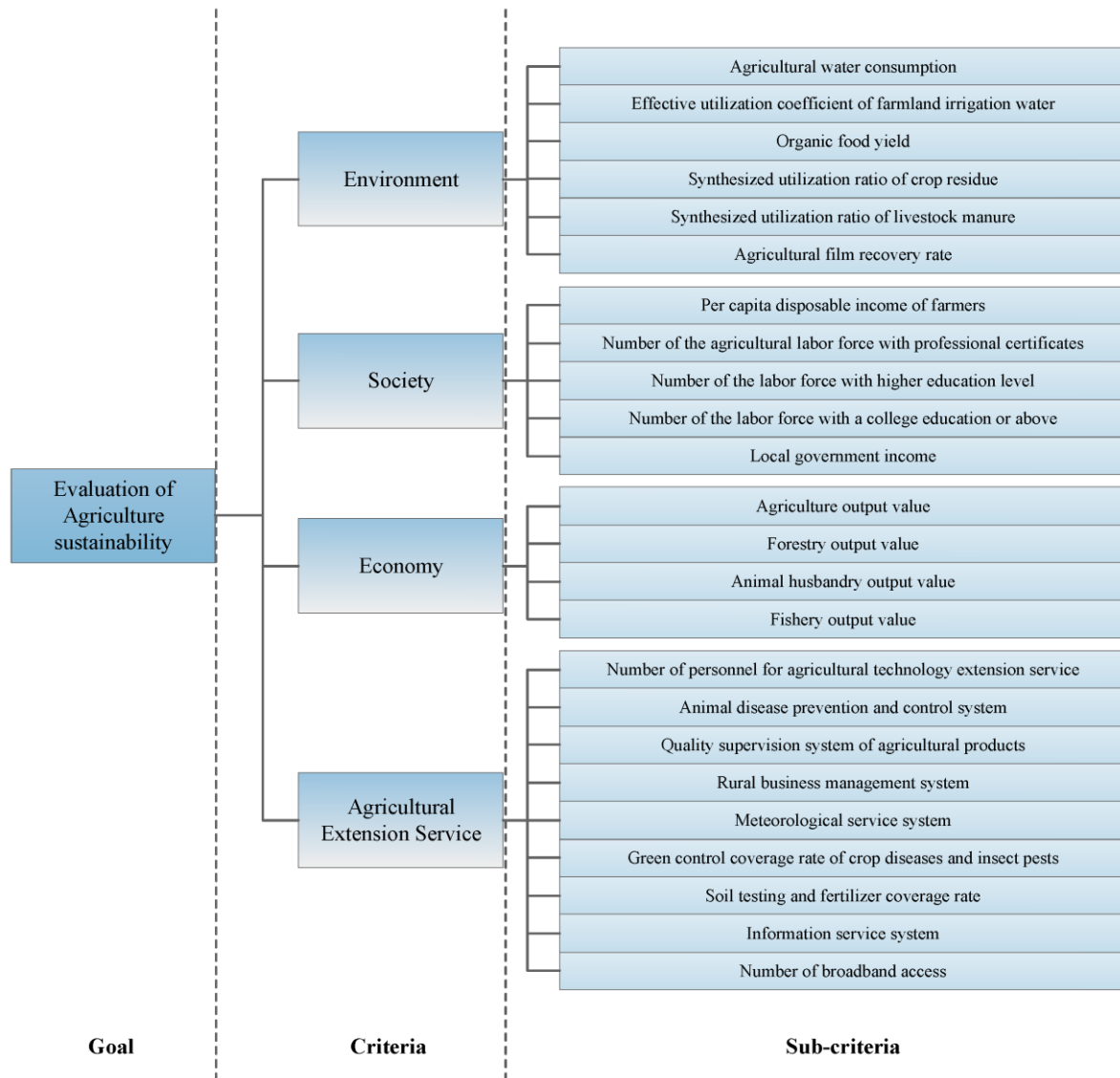


Fig. 1. The evaluation system of agricultural extension service (AES) for sustainable agriculture

posit agricultural extension as a system, emphasizing its interactive and complex nature [9]. Others have introduced terminologies like “Advisory Services,” focusing on the multiple actors and stakeholders involved in extension activities [10].

2.1 Key Theories and Models

Several theories and models have been used to explain the mechanisms and impact of agricultural extension services:

1. **Diffusion of Innovations:** Morgen [11] explored how innovations spread among members of a community. His theory

significantly impacted how extension services were designed and delivered.

2. **Agricultural Knowledge and Information Systems (AKIS):** This model views agricultural extension as part of a larger system, including research institutions, farmers, and the private sector [12].
3. **Human Capital Theory:** It posits that investment in education and training would result in increased productivity [13]. This theory is often cited to support the economic feasibility of extension services.
4. **The Treadmill of Production:** This theory offers a critical perspective, discussing how continuous technological innovation in

agriculture can lead to adverse ecological consequences [14].

3. SUSTAINABLE DEVELOPMENT IN AGRICULTURE

The essence of sustainable development in agriculture is to meet the current food needs while ensuring that resources are available for future generations (Table 1) [15]. Principles include economic viability, social equity, and environmental responsibility. Agroecological approaches, permaculture, and circular economies have been suggested as frameworks for achieving sustainable agriculture [16]. Various international bodies have incorporated these principles into global strategies. For instance, the United Nations' Sustainable Development Goals (SDGs) have specific targets for sustainable agriculture under Goal 2: "Zero Hunger". Indicators for sustainable agriculture often comprise a mix of environmental, social, and economic metrics [17]: Environmental, social, and economic factors serve as critical indicators for assessing the effectiveness and sustainability of agricultural extension services. Soil health, water quality, and biodiversity represent essential environmental parameters. Girardin *et al.* [18] emphasize that these ecological components are vital in judging the sustainability and environmental impact of agricultural practices. They directly influence crop health and yield, emphasizing the need for agricultural extension services to prioritize these factors in their programs. From a social perspective, factors like farmers' well-being, community cohesion, and equitable access to resources are indispensable. Velasco-Herrejon and Bauwens [19] point out that agricultural extension services not only need to disseminate technical information but also play a role in building socially cohesive and equitable communities. This focus ensures that the benefits of agricultural advancements are equitably distributed and serve to uplift entire communities, rather than isolated individuals or groups. Economic indicators, including profitability, yield per hectare, and value-added products, are another key focus area. Studies by Flora [20] highlight that these economic indicators serve as immediate and long-term measures of success for farmers. Profitability directly influences the livelihoods of farmers and their communities, while yield per hectare and the development of value-added products have broader implications for local and national economies. As such, agricultural extension

services that focus on improving these economic indicators can have a multi-layered impact, benefiting individual farmers and contributing to broader economic development.

4. ROLE OF AGRICULTURAL EXTENSION IN DEVELOPED COUNTRIES

4.1 Historical Perspective

The history of agricultural extension in developed countries can be traced back to early efforts in the late 19th and early 20th centuries, designed to disseminate agricultural knowledge and technology [21]. In the United States, the establishment of the Land-Grant University System in 1862 served as a cornerstone for extension services, laying the groundwork for the Smith-Lever Act of 1914 that formally launched the Cooperative Extension System [22]. In Europe, different models emerged. The United Kingdom, for instance, started with agricultural advisory services through the Board of Agriculture in the late 18th century [23]. Similarly, countries like Germany and France had extension services focusing primarily on transferring technology from research stations to farmers. Significant milestones include the introduction of the 'Training and Visit' (T&V) system in the 1970s [24] and more recently, the shift towards Integrated Pest Management (IPM) programs and the concept of sustainable agriculture [25].

4.2 Present Status

Government remains a key player in agricultural extension in developed countries. In the United States, for example, the Cooperative Extension Service funded by federal, state, and local governments continues to provide education and services to farmers [26]. Agencies like the Natural Resources Conservation Service (NRCS) offer specialized support in soil conservation and sustainable land use [27]. The Common Agricultural Policy (CAP) provides a framework for extension services in the European Union, often delivered through member states' Ministry of Agriculture or equivalent institutions. There are also EU-wide initiatives aimed at knowledge exchange and innovation in agriculture, such as the European Innovation Partnership (EIP-AGRI) [28]. The role of the private sector in agricultural extension is growing. This includes agribusiness companies providing specific technical advice related to their products, as well as consultancy

Table 1. Key aspects of sustainable development in agriculture

Category	Description	Examples	Benefits	Challenges
Sustainable Practices	Types of sustainable methods used in farming	Crop rotation, organic farming	Soil health, reduced chemical use	Initial cost, learning curve
Technology	Tech solutions aiding in sustainable agriculture	Drones, precision agriculture	Increases efficiency, reduces waste	Cost, accessibility
Economic Viability	Measures the economic feasibility of adopting sustainable practices	Cost-benefit analysis, subsidies	Long-term savings	Initial investment required
Social Impact	The socio-cultural effects of sustainable farming methods	Community engagement, education	Community upliftment, job creation	Resistance to change
Environmental Impact	The long-term effects on the environment	Reduced carbon footprint, soil conservation	Better for the planet	Monitoring and compliance
Policy & Regulations	Laws and policies that promote or hinder sustainable agriculture	Farm bills, land use policies	Can provide structural support	Bureaucratic delays, policy gaps
Energy Use	Energy efficiency and sources in sustainable agriculture	Solar-powered irrigation	Reduces reliance on fossil fuels	Initial setup costs
Water Management	Strategies for responsible water use	Rainwater harvesting, drip irrigation	Conservation of water resources	Water scarcity, cost
Biodiversity	Efforts to maintain or increase biodiversity	Polyculture, native planting	Resilience against pests, disease	Requires knowledge and expertise
Stakeholders Involved	Parties interested or invested in sustainable agriculture	Farmers, government, NGOs	Collaboration for better outcomes	Conflicting interests
Training and Education	Programs and resources for training farmers in sustainable practices	Workshops, online courses	Increased adoption of sustainable methods	Outreach, availability of quality content
Market Access	Availability of markets for sustainably produced goods	Farmers' markets, organic retail chains	Financial incentive for farmers	Competition, certification

services offering a range of services from farm management to precision agriculture [29]. Many times, the private sector partners with public institutions to offer these services. Companies like Monsanto and Syngenta, for example, have worked with universities to develop and disseminate new agricultural technologies [30].

4.3 Impact Assessment

The economic impact of agricultural extension in developed countries is substantial. Various

studies have found that extension services contribute significantly to increased agricultural productivity. For example, a study conducted in the United States found that for every dollar invested in agricultural extension, the return was \$20 in terms of additional farm income [31]. Similarly, research in European countries has shown that extension services have a strong positive correlation with higher yields and improved farm management [32]. Agricultural extension also plays a role in environmental conservation. Programs focused on sustainable

agriculture and natural resource management are now an integral part of extension services in many developed countries [33]. For example, Extension programs in Australia focusing on sustainable land and water management have helped mitigate the effects of salinity and soil erosion [34]. Extension services are increasingly seen as instrumental in promoting practices like conservation tillage, crop rotation, and integrated nutrient management, which have substantial environmental benefits [35].

5. ROLE OF AGRICULTURAL EXTENSION IN DEVELOPING COUNTRIES

5.1 Historical Background

Before the advent of colonial rule, agricultural extension services in developing countries operated informally, primarily rooted in indigenous knowledge systems [36]. These community-based forms of extension were vital in the dissemination of locally adapted agricultural practices [37]. During the colonial period, extension services became more formalized but were also employed as instruments of control [38]. In many African, Asian, and Latin American countries, the colonial administration used extension programs to promote cash crops that served the economic interests of the colonizers [39]. For example, in Kenya, the colonial agricultural policy focused on cash crops like tea and coffee, sidelining indigenous crops and practices [40].

5.2 Current Status

Government-run agricultural extension services are still the most widespread form of extension in many developing countries [41]. Countries like India have robust state extension systems that focus on a variety of crops and cater to a large number of farmers [42]. These systems often face challenges such as bureaucracy, limited funding, and a disconnect from localized issues. In recent years, governments have been exploring public-private partnerships (PPPs) to enhance the efficiency and reach of extension services [43]. For instance, the National Agricultural Advisory Services (NAADS) in Uganda is a semi-autonomous body that operates under a PPP model [44]. NGOs play a critical role in agricultural extension in developing countries. They often fill the gaps left by the government and focus on marginalized

communities [45]. Their work often includes introducing sustainable farming techniques, gender inclusion, and capacity building [46]. Examples include CARE's Pathways program in Africa and South Asia, which focuses on empowering female farmers [47].

5.3 Impact Evaluation

Agricultural extension services have significant social impacts in developing countries. They play an essential role in poverty reduction by empowering farmers through knowledge transfer [48]. They also contribute to social equality by targeting vulnerable groups such as women and minorities [49]. A study in Ethiopia indicated that extension services had led to improved social cohesion within farming communities [50]. Extension services are a key driver for agricultural productivity, which, in turn, contributes to economic growth [51]. Studies in China have shown that government extension programs were instrumental in the rapid growth of its agricultural sector [52]. Similarly, a review of extension services in Latin American countries like Brazil and Argentina indicates a strong correlation between extension services and increased farm productivity [53].

6. AGRICULTURAL EXTENSION AND TECHNOLOGY

The concept of technology transfer in agriculture has evolved over the years, adapting to the changing demands of the agricultural landscape. Traditional extension services have long been regarded as the most effective medium for the dissemination of new agricultural technologies [54]. One of the most widely applied models has been the "Training and Visit" (T&V) system, which focuses on periodic visits by extension agents to train farmers on new techniques and technologies [55]. Another model is the Farmer Field School (FFS), an approach developed by the Food and Agriculture Organization (FAO), emphasizing experiential learning and farmer participation [56]. This model has been particularly effective in transferring integrated pest management techniques [57]. The Participatory Extension Approach (PEA) is another model that emphasizes farmer participation and knowledge exchange among farmers themselves. This model empowers farmers to identify their own problems and develop solutions accordingly [58]. A more recent development is the Public-Private Partnership

(PPP) model, which brings together the strengths of public research institutions and private companies. This model often involves the dissemination of proprietary technologies developed by private companies through public extension services [59].

7. DIGITAL EXTENSION SERVICES

The proliferation of digital technology has significantly impacted the way agricultural extension services are delivered (Table 2). Mobile applications, for instance, have become a valuable tool for providing real-time information on weather, market prices, and best practices [60]. Applications such as iCow in Kenya and AgroTech in India have gained prominence for their role in providing crucial agricultural information directly to farmers [61]. Online

platforms have also become increasingly important. Websites and e-learning platforms offer a range of resources, including tutorial videos, webinars, and discussion forums that farmers can access at their convenience [62]. These platforms not only disseminate information but also serve as repositories where farmers can seek information as needed [63]. Social media platforms like Facebook, Twitter, and YouTube are being increasingly used in agricultural extension. These platforms offer a two-way communication channel where farmers can ask questions and receive immediate feedback [64]. They also serve as platforms for peer-to-peer knowledge exchange, where farmers share their experiences and learn from each other [65]. Some agricultural agencies have even started to use social media analytics to monitor trends and tailor their extension programs accordingly [66].

Table 2. Overview of digital extension services: types, technologies, and impact factors

Category	Description	Examples	Benefits	Challenges
Type of Service	Describes the kind of digital extension services offered	Virtual consultation, online forums	Caters to different needs	May require different expertise
Target Audience	Who the service is primarily aimed at	Farmers, business owners	Better focus and customization	Limited scalability
Technology Used	Platforms and technologies utilized	Mobile apps, web portals	Can be tailored to the audience	Technical glitches, maintenance
Cost	Overall cost or pricing model	Subscription, free trials	Can be affordable	May not be accessible to all
Accessibility	How easy it is for people to access and use the services	User-friendly UI, local language	Reaches a wider audience	May exclude non-tech-savvy individuals
Scalability	Potential for the service to grow and adapt	Cloud-based solutions	Can easily accommodate more users	May require additional resources
Security Measures	Measures taken to secure data and privacy	Encryption, two-factor authentication	Instills trust	Breaches can have severe consequences
Content Quality	The reliability and usefulness of the content provided	Expert-reviewed, data-driven	High value for the end-user	Requires continuous updates and validation
User Engagement	Features or methods used to engage users	Gamification, notifications	Higher retention and impact	Can become intrusive or annoying
Feedback Mechanism	Systems in place for receiving and incorporating feedback	Surveys, customer reviews	Constant improvement	Managing negative feedback

8. GENDER AND SOCIAL EQUITY IN AGRICULTURAL EXTENSION

8.1 Women in Agriculture

Women have historically played a crucial role in agriculture, making up approximately 43% of the agricultural labor force in developing countries [67]. Their roles vary from direct involvement in farming to post-harvest processes and marketing [68]. Despite their significant contributions, they often face challenges such as limited access to resources like land, credit, and agricultural extension services [69]. Gender-sensitive agricultural policies have started to address these gaps. Initiatives like the Gender Action Plan (GAP) of the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) aim to understand and rectify these challenges [70].

8.2 Minority Groups

Ethnic, racial, and other minority groups in agriculture also face unique challenges that are often overlaid with historical social and economic disparities [71]. Cultural barriers and a lack of representation in decision-making roles hinder the effectiveness of agricultural extension services for these groups [72]. Inclusion strategies like community-based participatory research (CBPR) have shown promise in more effective engagement with minority farmers [73].

8.3 Social Equity Models

Models like the Participatory Gender Analysis in Community Extension (PGACE) recommend adopting participatory and gender-sensitive methodologies to ensure that agricultural extension services are socially equitable [74]. Programs like USAID's "Feed the Future," employ such models to make agricultural extension services more accessible to women and minority groups [75].

9. CHALLENGES AND OPPORTUNITIES

9.1 Funding and Policy Gaps

Agricultural extension services have historically been funded through public resources, but budget allocations have declined over the years [76]. Current policy frameworks often fail to prioritize extension services adequately, leading

to a resource-constrained environment [77]. Public-Private Partnerships (PPP) have emerged as an alternative funding model but come with their own set of challenges such as the commercialization of research outcomes [78].

9.2 Climate Change and Sustainability

Climate change poses significant challenges to the agricultural sector, impacting yield, water availability, and pest dynamics [79]. Agricultural extension services have a role in imparting climate-smart agricultural practices, but these services themselves are hindered by global warming, affecting the efficacy of traditional extension methods [80]. Extension services need to adapt and evolve in terms of how they engage with farmers about sustainable and climate-resilient practices [81].

9.3 Future Opportunities

Technological innovations like digital extension platforms offer opportunities for modernizing and enhancing the reach of agricultural extension services [82]. Artificial Intelligence (AI) and Machine Learning (ML) have the potential to revolutionize data-driven decision-making in agriculture [83].

10. CONCLUSION

The effectiveness of agricultural extension services can be comprehensively assessed through a triad of environmental, social, and economic indicators. Environmental factors like soil health and biodiversity are not just ecological concerns but are directly tied to agricultural productivity. Social factors, such as community cohesion and equitable resource access, extend the role of extension services beyond mere technical advisories to being agents of social change. Economic indicators like profitability and yield underscore the material success of agricultural practices, influencing both individual livelihoods and broader economic structures. By adopting a multi-faceted approach that integrates these three key areas, agricultural extension services can aim for a more sustainable and equitable form of agriculture that benefits both the land and its people.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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