

## Review Article

### A Comprehensive Review On Role Of Agricultural Extension Services In The Sustainable Development Of Global Agriculture.

**Comment [Z1]:** The title is good (16 words)

#### Abstract

In an era where agriculture faces unprecedented challenges, from climate change to increasing food demands, this paper aims to re-evaluate the current paradigms governing agricultural extension services critically. These services are instrumental in bridging the gap between agricultural research and practical farming, catalyzing 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 contemporary agriculture's complex, interrelated challenges and opportunities. 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.

**Comment [Z2]:** Abstract is good (275 words), It is recommended that the abstract be a maximum of 250 words, sentences can be simplified

**Keywords:** Agriculture, Extension, Metrics Multidimensional, Sustainability

**Comment [Z3]:** Keywords are good (4 words), maximum keyword is five words, you can add one important word

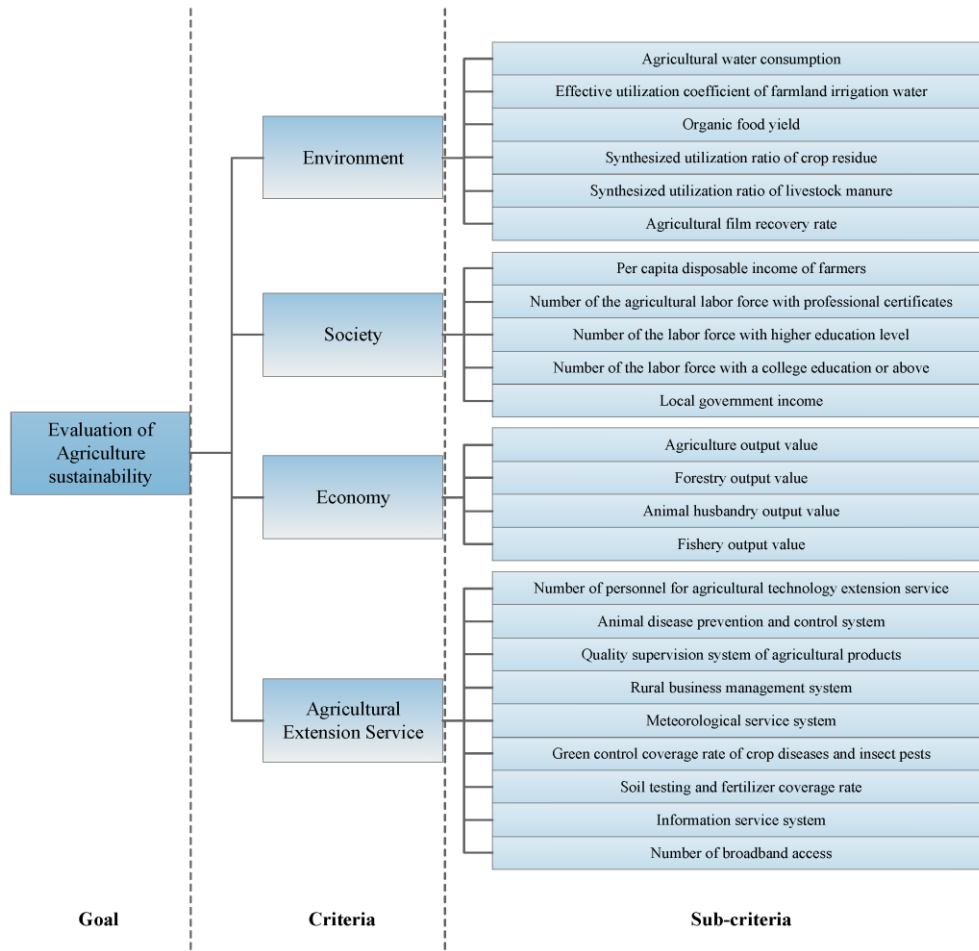
#### Introduction

Agricultural extension services have a long and varied history, dating back to the late 19th century [1]. For example, the formalization of agricultural extension services in the United States 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 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, increasing resource stress. The role of agricultural extension services in facilitating sustainable practices is critical [4]. This review paper will broadly examine agricultural extension services globally, focusing on 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 examines the historical context, evaluates current status, identifies challenges, and forecasts 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 of original research articles to policy briefs.

**Comment [Z4]:** Introduction is good

UNDER PEER REVIEW



**Figure 1:** The agricultural extension service (AES) evaluation system for sustainable agriculture.

### Literature Review

Agricultural extension services can be defined as 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 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].

### **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 community members. 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 more extensive system, including research institutions, farmers, and the private sector [12].
3. **Human Capital Theory** posits that investment in education and training would increase 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].

### **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 agricultural practices' sustainability and environmental impact. 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 need to disseminate technical information and play a role in building socially

**Comment [Z5]:** Articles must include Introduction, Methods, Results, discussion, and conclusion. It is recommended that after the literature review the research method be added and the title of the research results and discussion also added. After that, the conclusion continues

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.

**Table 1.** Critical 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	Parties interested or	Farmers,	Collaboration for	Conflicting

Involved	invested in sustainable agriculture	government, NGOs	better outcomes	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

## Role of Agricultural Extension in Developed Countries

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### 1. Historical Perspective

The history of agricultural extension in developed countries can be traced back to early efforts to disseminate agricultural knowledge and technology in the late 19th and early 20th centuries [21]. Established the Land-Grant University System in the United States in 1862 was 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 18<sup>th</sup> 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].

### 2. Present Status

The 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 providing 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 and consultancy services offering various services from farm management to precision agriculture [29]. The private sector often partners with public institutions to offer these services. For

example, companies like Monsanto and Syngenta have worked with universities to develop and disseminate new agricultural technologies [30].

### **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 for 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 integral to 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].

### **Role of Agricultural Extension in Developing Countries**

#### **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 extension forms were vital in disseminating locally adapted agricultural practices [37]. During the colonial period, extension services became more formalized but were also employed as control instruments [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, the colonial agricultural policy in Kenya focused on cash crops like tea and coffee, sidelining indigenous crops and practices [40].

#### **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 various crops and cater to many farmers [42]. These systems often face 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, Uganda's National Agricultural Advisory Services (NAADS) 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].

### **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 improved social cohesion within farming communities [50]. Extension services are a crucial 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].

#### **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 disseminating 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) that emphasizes experiential learning and farmer participation [56]. This model has effectively transferred 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 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 disseminating proprietary technologies developed by private companies through public extension services [59].

#### **Digital Extension Services**

The proliferation of digital technology has significantly impacted how 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 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 disseminate information and serve as repositories where

farmers can seek information as needed [63]. Social media platforms like Facebook, Twitter, and YouTube are 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	It 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	It 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	This may exclude non-tech-savvy individuals
Scalability	Potential for the service to grow and adapt	Cloud-based solutions	Can easily accommodate more users	It 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	It can become intrusive or annoying
Feedback Mechanism	Systems in place for receiving and incorporating feedback	Surveys, customer reviews	Constant improvement	Managing negative feedback

## Gender and Social Equity in Agricultural Extension

### 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 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].

## **2. Minority Groups**

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

## **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].

## **Challenges and Opportunities**

### **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 challenges, such as the commercialization of research outcomes [78].

### **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 regarding how they engage with farmers about sustainable and climate-resilient practices [81].

### 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].

#### 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.

**Comment [Z7]:** Conclusion is good

#### References:

**Comment [Z8]:** References are good

1. Foster, D., Swanson, F., Aber, J., Burke, I., Brokaw, N., Tilman, D., & Knapp, A. (2003). The importance of land-use legacies to ecology and conservation. *BioScience*, 53(1), 77-88.
2. Portes, A., Haller, W. J., & Guarnizo, L. E. (2002). Transnational entrepreneurs: An alternative form of immigrant economic adaptation. *American Sociological Review*, 278-298.
3. Grosso, G., Mateo, A., Rangelov, N., Buzeti, T., & Birt, C. (2020). Nutrition in the Context of the Sustainable Development Goals. *European Journal of Public Health*, 30(Supplement\_1), i19-i23.
4. Raidimi, E. N., & Kabiti, H. M. (2019). A review of the role of agricultural extension and training in achieving sustainable food security: A case of South Africa. *South African Journal of Agricultural Extension*, 47(3), 120-130.
5. Kanwar, A., Balasubramanian, K., & Carr, A. (2019). Changing the TVET paradigm: new models for lifelong learning. *International Journal of Training Research*, 17(sup1), 54-68.
6. Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., ... & Cohen, M. (2009). From best practice to best fit: A framework for designing and analyzing pluralistic agricultural advisory services worldwide. *Journal of agricultural education and extension*, 15(4), 341-355.

7. Mwangi, M., & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development*, 6(5).
8. Al-Tabbaa, O., & Ankrah, S. (2016). Social capital to facilitate 'engineered-industry collaboration for technology transfer: A dynamic perspective. *Technological Forecasting and Social Change*, 104, 1-15.
9. Carlisle, K., & Gruby, R. L. (2019). Polycentric systems of governance: A theoretical model for the commons. *Policy Studies Journal*, 47(4), 927-952.
10. Fanzo, J., Marshall, Q., Dobermann, D., Wong, J., Merchan, R. I., Jaber, M. I., ... & Davis, K. (2015). Integration of nutrition into extension and advisory services: a synthesis of experiences, lessons, and recommendations. *Food and Nutrition Bulletin*, 36(2), 120-137.
11. Morgan, K. (2007). The learning region: institutions, innovation, and regional renewal. *Regional studies*, 41(S1), S147-S159.
12. Sulaiman, V. R., & Hall, A. (2002). Beyond technology dissemination: reinventing agricultural extension. *Outlook on Agriculture*, 31(4), 225-233.
13. Njoroge, C. W., & Gathungu, J. M. (2013). The effect of entrepreneurial education and training on the development of small and medium-sized enterprises in Githunguri District-Kenya. *International Journal of Education and Research*, 1(8), 1-22.
14. Schnaiberg, A., Pellow, D. N., & Weinberg, A. (2002). The treadmill of production and the environmental state. *The environmental state under pressure*, 10, 15-32.
15. Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, 5(1), 1653531.
16. Krebs, J., & Bach, S. (2018). Permaculture—Scientific evidence of principles for the agroecological design of farming systems. *Sustainability*, 10(9), 3218.
17. Rigby, D., Woodhouse, P., Young, T., & Burton, M. (2001). Constructing a farm-level indicator of sustainable agricultural practice. *Ecological economics*, 39(3), 463-478.
18. Girardin, P., Bockstaller, C., & Van der Werf, H. (2000). Assessment of potential impacts of agricultural practices on the environment: the AGRO\* ECO method. *Environmental Impact Assessment Review*, 20(2), 227-239.
19. Velasco-Herrejon, P., & Bauwens, T. (2020). Energy justice from the bottom up: A capability approach to community acceptance of wind energy in Mexico. *Energy Research & Social Science*, 70, 101711.

20. Flora, C. B. (2018). Building sustainable agriculture: a new application of farming systems research and extension. *Integrating sustainable agriculture, ecology, and environmental policy* (pp. 37-49). Routledge.
21. Kuznets, S. (1973). Modern economic growth: findings and reflections. *The American Economic Review*, 63(3), 247-258.
22. Kuznets, S. (1973). Modern economic growth: findings and reflections. *The American Economic Review*, 63(3), 247-258.
23. Reichard, S. H., & White, P. (2001). Horticulture as a pathway of invasive plant introductions in the United States: Most invasive plants have been introduced for horticultural use by nurseries, botanical gardens, and individuals. *BioScience*, 51(2), 103-113.
24. Singh, K. M., & Swanson, B. (2006, May). Developing market-driven extension system in India. In *Proceedings of 22nd Annual Conference of Association of International Agricultural and Extension Education (AIAEE), Florida, USA* (pp. 627-637).
25. Röling, N., & Van De Fliert, E. (1994). Transforming extension for sustainable agriculture: the case of integrated pest management in rice in Indonesia. *Agriculture and Human Values*, 11, 96-108.
26. 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.
27. Renschler, C. S., & Harbor, J. (2002). Soil erosion assessment tools from point to regional scales—the role of geomorphologists in land management research and implementation. *Geomorphology*, 47(2-4), 189-209.
28. Fieldsend, A. F., Cronin, E., Varga, E., Biró, S., & Rogge, E. (2021). 'Sharing the space' in the agricultural knowledge and innovation system: multi-actor innovation partnerships with farmers and foresters in Europe. *The journal of agricultural education and extension*, 27(4), 423-442.
29. Dobrinsky, R. (2019). *European Innovation Partnerships: How Successful Have They Been in Promoting Innovation in the EU?* (No. 438). wiiw Research Report.
30. Bull, E. M., van der Cruyssen, L., Vágó, S., Király, G., Arbour, T., & van Dijk, L. (2022). Designing for agricultural digital knowledge exchange: applying a user-centered design approach to understand users' needs. *The Journal of Agricultural Education and Extension*, 1-26.
31. Peterson, W. L. (1967). Return to poultry research in the United States. *American Journal of Agricultural Economics*, 49(3), 656-669.

32. Derpsch, R., Friedrich, T., Kassam, A., & Li, H. (2010). Current status of adoption of no-till farming in the world and some of its main benefits. *International journal of agricultural and biological engineering*, 3(1), 1-25.
33. Dixon, J., Nalley, L., Kosina, P., La Rovere, R., Hellin, J., & Aquino, P. (2006). Adoption and economic impact of improved wheat varieties in the developing world. *The Journal of Agricultural Science*, 144(6), 489-502.
34. Qadir, M., Quill rou, E., Nangia, V., Murtaza, G., Singh, M., Thomas, R. J., ... & Noble, A. D. (2014, November). Economics of salt- induced land degradation and restoration. In *Natural resources forum* (Vol. 38, No. 4, pp. 282-295).
35. Veisi, H. (2012). Exploring the determinants of adoption behavior of clean technologies in agriculture: a case of integrated pest management. *Asian Journal of Technology Innovation*, 20(1), 67-82.
36. Aubert, J. E. (2005). *Promoting innovation in developing countries: a conceptual framework* (Vol. 3554). World Bank Publications.
37. Walter, P. (2009). Local knowledge and adult learning in environmental adult education: Community- based ecotourism in southern Thailand. *International Journal of Lifelong Education*, 28(4), 513-532.
38. Agarwal, B. (2019). The gender and environment debate: Lessons from India. In *Population and environment* (pp. 87-124). Routledge.
39. Parmar, A., Sturm, B., & Hensel, O. (2017). Crops that feed the world: Production and improvement of cassava for food, feed, and industrial uses. *Food Security*, 9, 907-927.
40. Rondinelli, D. A. (1983). Dynamics of growth of secondary cities in developing countries. *Geographical Review*, 42-57.
41. Thakur, D., & Chander, M. (2018). Use of social media in agricultural extension: Some evidence from India. *International Journal of Science, Environment, and Technology*, 7(4), 1334-1346.
42. Mohan, R. (2006). Agricultural credit in India: Status, issues and future agenda. *Economic and Political Weekly*, 1013-1023.
43. Brinkerhoff, D. W., & Brinkerhoff, J. M. (2011). Public-private partnerships: Perspectives on purposes, publicness, and good governance. *Public administration and development*, 31(1), 2-14.
44. Naluwairo, R. (2011). Promoting Agriculture Sector Growth and Development: A Comparative Analysis of Uganda's Political Party Manifestos (2011-2016).

45. Davis, K., & Place, N. (2003). Non-governmental organizations are an important factor in agricultural extension in semiarid East Africa. *Journal of International Agricultural and Extension Education*, 10(1), 31-36.
46. Wahab, A. A. I., Issa, F. O., Baba, D., Kudingi, T. A., Adamu, M., & Ibegbulem, J. A. (2011). NGOs and CBOs Structures and Mechanism for Collaboration in Agricultural Extension Delivery in Nigeria. *Journal of Agricultural Extension*, 15(2), 79-89.
47. Swanson, B. E. (2009). Changing extension paradigms within a rapidly changing global economy. In *Proceedings of the 19th European seminar on extension education: Theory and practice of advisory work in a time of Turbulences* (pp. 113-117).
48. Aker, J. C. (2011). Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. *Agricultural economics*, 42(6), 631-647.
49. Mapiye, O., Makombe, G., Molotsi, A., Dzama, K., & Mapiye, C. (2021). Towards a revolutionized agricultural extension system for the sustainability of smallholder livestock production in developing countries: The potential role of its. *Sustainability*, 13(11), 5868.
50. Feder, G., Anderson, J. R., Birner, R., & Deininger, K. (2010). Promises and realities of community-based agricultural extension. In *Community, market and state in development* (pp. 187-208). London: Palgrave Macmillan UK.
51. Nkonya, E., Johnson, T., Kwon, H. Y., & Kato, E. (2016). Economics of land degradation in sub-Saharan Africa. *Economics of land degradation and improvement—a global assessment for sustainable development*, 215-259.
52. Garschagen, M., Diez, J. R., Nhan, D. K., & Kraas, F. (2012). Socio-economic development in the Mekong Delta: between the prospects for progress and the realms of reality. *The Mekong Delta system: Interdisciplinary analyses of a river delta*, 83-132.
53. Emran, S. A., Krupnik, T. J., Aravindakshan, S., Kumar, V., & Pittelkow, C. M. (2021). Factors contributing to farm-level productivity and household income generation in coastal Bangladesh's rice-based farming systems. *PloS one*, 16(9), e0256694.
54. Holzworth, D. P., Huth, N. I., deVoil, P. G., Zurcher, E. J., Herrmann, N. I., McLean, G., ... & Keating, B. A. (2014). APSIM—evolution towards a new generation of agricultural systems simulation. *Environmental Modelling & Software*, 62, 327-350.
55. Knickel, K., Brunori, G., Rand, S., & Proost, J. (2009). Towards a better conceptual framework for innovation processes in agriculture and rural development: from linear models to systemic approaches. *Journal of agricultural education and extension*, 15(2), 131-146.

56. Shiferaw, B. A., Okello, J., & Reddy, R. V. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Environment, development and sustainability*, 11, 601-619.
57. Minh, T. T., Larsen, C. E. S., & Neef, A. (2010). Challenges to institutionalizing participatory extension: The case of farmer livestock schools in Vietnam. *Journal of Agricultural Education and Extension*, 16(2), 179-194.
58. Kaur, K., & Kaur, P. (2018). Agricultural extension approaches to enhance the knowledge of farmers. *International Journal of Current Microbiology and Applied Sciences*, 7(2), 2367-2376.
59. David, S., & Asamoah, C. (2011). Video as a tool for agricultural extension in Africa: a case study from Ghana. *International Journal of Education and Development using Information and Communication Technology*, 7(1), 26.
60. Rajkhowa, P., & Qaim, M. (2021). Personalized digital extension services and agricultural performance: Evidence from smallholder farmers in India. *PloS one*, 16(10), e0259319.
61. Mushtaq, S., Reardon-Smith, K., Cliffe, N., Ostini, J., Farley, H., Doyle, J., & Kealley, M. (2017). Can digital discussion support tools provide cost-effective options for agricultural extension services? *Information Technologies & International Development*, 13, 17.
62. Fabregas, R., Harigaya, T., Kremer, M., & Ramrattan, R. (2022). Digital agricultural extension for development. In *Introduction to Development Engineering: A Framework with Applications from the Field* (pp. 187-219). Cham: Springer International Publishing.
63. Boyaci, M., & Yildiz, O. (2016). An overview of agricultural extension services in Turkey. *Bulg. J. Agric. Sci*, 22, 151-157.
64. Tang, Z., Zhang, L., Xu, F., & Vo, H. (2015). Examining the role of social media in California's drought risk management in 2014. *Natural Hazards*, 79, 171-193.
65. Chowdhury, A., & Odame, H. H. (2013). Social media for enhancing innovation in agri-food and rural development: Current dynamics in Ontario, Canada. *Journal of Rural and Community Development*, 8(2).
66. Kandagor, J. C., Githeko, J. M., & Opiyo, A. M. (2018). Usability attributes influencing the adoption and use of mobile apps for dissemination of agricultural information. *International Journal of Agricultural Extension*, 6(1), 33-41.
67. Allen, P., & Sachs, C. (2007). Women and food chains: The gendered politics of food. *The International Journal of Sociology of Agriculture and Food*, 15(1), 1-23.

68. Beneria, L., & Sen, G. (1981). Accumulation, reproduction, and "women's role in economic development": Boserup revisited. *Signs: Journal of women in culture and society*, 7(2), 279-298.
69. Benanav, A. (2019). Demography and Dispossession: Explaining the Growth of the Global Informal Workforce, 1950-2000. *Social Science History*, 43(4), 679-703.
70. Jafry, T., & Sulaiman V, R. (2013). Gender-sensitive approaches to extension program design. *The Journal of Agricultural Education and Extension*, 19(5), 469-485.
71. Méndez, M., Flores-Haro, G., & Zucker, L. (2020). The (in) visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and indigenous immigrants. *Geoforum*, 116, 50-62.
72. Hora, E. A. (2014). Factors that affect women participation in leadership and decision making position. *Asian Journal of Humanity, Art and Literature*, 1(2).
73. Kaaria, S., Osorio, M., Wagner, S., & Gallina, A. (2016). Rural women's participation in producer organizations: An analysis of the barriers that women face and strategies to foster equitable and effective participation. *Journal of Gender, Agriculture and Food Security (Agri-Gender)*, 1(302-2016-4754), 148-167.
74. Solon, J. J. C., Cantina, J. M., Van Ryan, I. A., Sarzuelo, J. G. R., Velasco, P. E., & Mancera, M. K. J. (2023). Gender Equity Landscape In Higher Education During Pandemic Years: Linking Organizational Practices To Teachers' morale And Productivity. *Sprin Journal of Arts, Humanities and Social Sciences*, 2(01), 23-57.
75. Zakaria, H. (2017). The drivers of women farmers' participation in cash crop production: the case of women smallholder farmers in Northern Ghana. *The Journal of Agricultural Education and Extension*, 23(2), 141-158.
76. Feder, G., Willett, A., & Zijp, W. (1999). *Agricultural Extension: Generic Challenges and the Ingredients for Solutions* (Vol. 2129). World Bank Publications.
77. Feder, G., Willett, A., & Zijp, W. (2001). *Agricultural extension: Generic challenges and the ingredients for solutions* (pp. 313-353). Springer US.
78. Wilson, E., Nielsen, N., & Buultjens, J. (2009). From lessees to partners: Exploring tourism public-private partnerships within the New South Wales national parks and wildlife service. *Journal of Sustainable Tourism*, 17(2), 269-285.
79. Skendžić, S., Zovko, M., Živković, I. P., Lešić, V., & Lemić, D. (2021). The impact of climate change on agricultural insect pests. *Insects*, 12(5), 440.
80. Aggarwal, P. K. (2008). Global climate change and Indian agriculture: impacts, adaptation, and mitigation. *Indian Journal of Agricultural Sciences*, 78(11), 911.

81. Pathak, T. B., Maskey, M. L., Dahlberg, J. A., Kearns, F., Bali, K. M., & Zaccaria, D. (2018). Climate change trends and impacts on California agriculture: A detailed review. *Agronomy*, 8(3), 25.
82. Bhattacharjee, S., & Raj, S. (2016). Social media: Shaping the future of agricultural extension and advisory services. *GFRAS interest group on ICT4RAS discussion paper, GFRAS: Lindau, Switzerland*, 9.
83. Fabregas, R., Kremer, M., & Schilbach, F. (2019). Realizing the potential of digital development: The case of agricultural advice. *Science*, 366(6471), eaay3038.

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