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Agricultural extension system: A bibliometric analysis

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Abstract

Agricultural extension systems are crucial for rural development, empowering farmers, promoting sustainable practices, and enabling knowledge sharing. This study presents a bibliometric analysis of research from 2019-2024, based on 221 refined documents from an initial 678. Sixty primary sources formed the core analysis, revealing a 22.47% annual growth rate and an average citation rate of 8.533 per document. A total of 814 authors, with 4.7 authors per document and nine single-authored papers, highlight strong collaboration. Thematic diversity is evident with 642 keywords, covering stakeholder engagement, digital tools, capacity building, and policy. International collaboration accounts for 35.71% of papers, emphasizing global challenges like food security and climate adaptation. Trends show increased use of mobile services and AI in extension. Yet, gaps remain in addressing local issues, especially in resource-poor areas. Future research should focus on contextual solutions, gender inclusion, and scalable innovations to ensure equitable and sustainable agricultural extension systems.

Keywords: Agricultural extension, bibliometric analysis, rural development, sustainability, stakeholder engagement, digital tools, international collaboration, knowledge dissemination, capacity building, food security

1 Introduction

Agricultural extension services have long served as a cornerstone for the development of sustainable agricultural practices, technological adoption, and farmer empowerment globally. These services act as a bridge between research institutions and farming communities, ensuring that farmers have access to the knowledge, tools, and strategies required to optimize productivity and adapt to changing environments. As the global agricultural landscape evolves, the demands on extension systems have become increasingly complex, requiring innovative and inclusive approaches to address the myriad challenges faced by farmers across different regions.

In this context, understanding the dynamics of agricultural extension services, their evolution, and the diverse models employed worldwide becomes essential for designing systems that are resilient, responsive, and equitable. Numerous studies have explored various aspects of agricultural extension, shedding light on successes, challenges, and opportunities for reform. This introduction synthesizes key findings from these studies, providing an overview of the multifaceted approaches to agricultural extension and their relevance to global food security, climate resilience, and sustainable development.

The Evolving Role of Agricultural Extension Services

The role of agricultural extension services has undergone significant transformations over the years, shifting from traditional top-down approaches to more participatory and technology-driven models. Blum *et al.* (2020) ^[14] highlight this global transition, emphasizing the increasing use of participatory frameworks and digital technologies to enhance inclusivity and adaptability. Similarly, Laurens *et al.* document the evolution of pluralistic extension systems in Latin America, which integrate multiple advisory providers to address the diverse needs of farmers in countries like Argentina, Brazil, Costa Rica, and Mexico. These studies underscore the necessity for extension systems to remain dynamic and responsive to the socio-economic and technological changes shaping agriculture. In India, Gulati *et al.* (2018) ^[18] note the growing emphasis on Information and Communication Technology (ICT) tools and participatory approaches within extension services. The authors argue that involving farmers in planning and innovation processes is crucial to ensuring the relevance and effectiveness of extension initiatives. This perspective is echoed by Mukherjee and Modak (2022) ^[24], who advocate for adopting emerging paradigms such as digital extension and community-based models to make Indian agricultural extension more adaptable to modern challenges.

Addressing Climate Resilience and Sustainability

Climate change poses a significant threat to global agriculture, necessitating the integration of climate resilience strategies into extension services. Antwi-Agyei and Stringer (2021) ^[1] highlight the critical role of extension agents in Ghana in communicating climate information to farmers. Their study emphasizes the importance of capacity-building initiatives to empower extension agents with the skills needed to enhance farmers' resilience against climate risks. By enabling informed decision-making, such efforts contribute to the development of resilient farming communities better equipped to adapt to climatic changes. Sustainability is another key focus area for extension services. Sahu *et al.* (2023) ^[5] present a comprehensive review of how extension services promote sustainable agricultural practices, including resource efficiency, conservation, and eco-friendly farming methods. The authors argue that prioritizing sustainability education within extension efforts is essential for achieving global sustainability goals. This aligns with the findings of Hossain and Siddique (2020) ^[19], who highlight the role of precision agriculture and digital tools in optimizing resource use and minimizing environmental impact in Bangladesh.

Policy Reforms and Structural Challenges

Policy reforms are critical for enhancing the efficiency and effectiveness of agricultural extension services. Ashokkumar and Naik (2021) ^[2] provide an overview of recent reforms in India, highlighting the structural and operational changes aimed at improving service delivery to farmers. Despite these efforts, challenges such as staffing shortages, limited reach, and integration issues persist. Babu *et al.* (2013) ^[3] echo these concerns, identifying similar challenges in Indian states like Bihar, Himachal Pradesh, Maharashtra, and Tamil Nadu. Both studies emphasize the need for decentralized management and collaborative partnerships to create a more demand-driven extension system.

In Egypt, Diab *et al.* (2020) ^[10] identify inefficiencies in the centralized management of extension services and advocate for a decentralized framework to improve responsiveness and service quality. Likewise, Davidson and Ahmad (2002) ^[8] compare public and private extension models in Pakistan, proposing a hybrid approach that combines the efficiency of private providers with the inclusivity of public services. These studies highlight the importance of policy and structural reforms in overcoming the inherent limitations of existing extension systems.

Integrating Technology and Innovation

The integration of technology into agricultural extension has emerged as a transformative trend. Gao *et al.* (2020) and Hu *et al.* (2020) ^[12] examine the role of technology in Chinese extension services, noting significant improvements in technology adoption and farmer-centered approaches. Gao *et al.* (2020) ^[12] emphasize the importance of tailoring extension efforts to promote locally relevant technologies, while Hu *et al.* (2018) ^[20] trace the historical evolution of Chinese extension from a state-controlled model to a market-oriented, participatory system.

In India, Chowdary *et al.* (2024) ^[11] explore the impact of social media on digital extension, revealing that platforms

like WhatsApp and Facebook have become essential tools for real-time information sharing and farmer engagement. The authors recommend further investment in social media training for extension agents to maximize its potential. Similarly, Yusuf *et al.* (2022) ^[6] analyze how alternative media channels supported extension services in South Africa during the COVID-19 pandemic, demonstrating the effectiveness of digital and broadcast media in reaching farmers during crises.

Participatory and Community-Based Approaches

Participatory and community-based approaches have gained prominence as effective alternatives to traditional extension models. Neza *et al.* (2022) ^[22] explore the Twigire Muhinzi program in Rwanda, a farmer field school model that emphasizes peer-to-peer learning and hands-on training. The program's success in fostering knowledge exchange highlights the potential of participatory approaches in strengthening agricultural extension.

In Ethiopia, Getahun and Milkias (2021) ^[16] review the cluster farming approach, which organizes farmers into clusters to streamline resource use and improve market access. This model promotes collective action and resource sharing, making it a scalable strategy for enhancing productivity and efficiency. Similarly, Camillone *et al.* (2020) ^[7] emphasize the role of collaboration between researchers, extension agents, and farmers in addressing food security challenges in Nigeria. These studies demonstrate the value of community-based approaches in creating resilient and inclusive extension systems.

Private Sector Involvement and Public-Private Partnerships

The involvement of the private sector in agricultural extension has become increasingly significant in addressing resource constraints and enhancing service delivery. Nwafor *et al.* (2021) ^[23] examine the role of private advisory services in Sub-Saharan Africa, highlighting their complementary role to public extension. The authors advocate for stronger collaboration between public and private sectors to create a comprehensive and sustainable extension system.

In Bangladesh, Karim and Noman (2018) ^[21] identify policy gaps that hinder the delivery of extension services and recommend exploring public-private partnerships as a potential solution. Hamisu *et al.* (2017) ^[15] echo this sentiment in their review of Nigerian extension services, emphasizing the need for sustainable funding and community-based models to strengthen service delivery. These studies underscore the potential of public-private partnerships in overcoming the limitations of traditional extension systems.

Regional and Context-Specific Insights

Extension services must be tailored to the specific needs and challenges of different regions to maximize their impact. Dhehibi *et al.* (2020) ^[9] explore farmers' preferences for technology transfer in Tunisia's arid regions, highlighting the importance of affordable and practical solutions. The authors argue that aligning extension efforts with local conditions is essential for fostering technology adoption and improving agricultural productivity.

Ghimire *et al.* (2014) ^[17] compare government and university-managed extension services in Nepal, India, and the USA, identifying strengths and weaknesses in each system. The authors suggest that blending elements from both models could enhance service effectiveness. Gatdet (2022) ^[13] employs a mixed-methods approach to evaluate Ethiopian extension services, recommending a combination of quantitative and qualitative methods to address social and economic needs comprehensively. These studies emphasize the need for context-specific strategies to ensure the relevance and effectiveness of extension services. The studies reviewed highlight the multifaceted nature of agricultural extension services and their critical role in addressing global agricultural challenges. From integrating technology and promoting sustainability to implementing policy reforms and fostering participatory approaches, the insights from these studies provide valuable guidance for designing effective extension systems. By addressing regional needs, leveraging private sector involvement, and incorporating innovative models, extension services can play a pivotal role in achieving food security, climate resilience, and sustainable development. As the global agricultural landscape continues to evolve, the lessons from these studies underscore the importance of adaptive, inclusive, and farmer-centered approaches to agricultural extension.

Methodology for Bibliometric Analysis

The methodology for conducting a bibliometric analysis in this study focuses on using quantitative measures to evaluate and synthesize the academic landscape of agricultural extension systems globally. Bibliometric analysis is an effective tool for identifying trends, patterns, and gaps in research across various disciplines. By leveraging this approach, the study aims to uncover critical insights into the scholarly advancements, collaboration networks, and thematic diversity within the domain of agricultural extension. This methodology integrates data collection, filtering processes, and comprehensive analysis to provide an accurate and systematic overview of the field.

Data Collection and Sources

To ensure a comprehensive understanding of the recent trends in agricultural extension systems, data were meticulously collected from multiple academic databases. These included Scopus, Web of Science, and Google Scholar, which are recognized for their extensive coverage and credibility in academic research. Publications spanning the period from 2020 to 2024 were targeted to focus on the latest developments, ensuring that the analysis reflects contemporary perspectives and practices.

The search strategy employed a combination of keywords and Boolean operators to maximize the breadth of relevant documents retrieved. The key search terms included: "Extension Services," OR "Farm Advisory Services," OR "Advisory Services," OR "Agricultural Innovation System," AND "Trends," OR "Status," OR "Challenges." These keywords were carefully chosen to capture a wide array of research outputs, encompassing diverse aspects of agricultural extension systems, including their evolution, operational challenges, and current trends.

Scope and Filters

From an initial pool of 678 documents retrieved across the selected databases, a systematic filtering process was applied to refine the dataset. This step ensured the inclusion of high-quality and relevant studies that align closely with the research objectives. The following criteria were used for filtering:

1. **Publication Date:** Only documents published between 2019 and 2024 were considered to capture the most recent and relevant findings.
2. **Language:** Publications in English were prioritized to maintain consistency in analysis and interpretation.
3. **Journal Relevance:** Articles published in journals with a focus on agricultural sciences, rural development, and related interdisciplinary domains were included to ensure subject relevance.

After applying these filters, the document pool was narrowed down to 221 publications. These studies represented a diverse range of perspectives, methodologies, and thematic focuses, providing a robust foundation for the bibliometric analysis.

Systematic Review and Selection Process

The systematic review process aimed to identify the most impactful and relevant studies within the refined dataset. Out of the 221 publications, 60 primary sources were selected for in-depth examination. These sources were chosen based on their contribution to advancing knowledge in agricultural extension systems, as evidenced by citation impact, thematic relevance, and methodological rigor. Additionally, 182 key documents were analyzed to map the development and scholarly trajectory of the field over recent years. This comprehensive review provides a detailed understanding of the challenges, trends, and innovations shaping agricultural extension systems globally.

To further enhance the focus on contemporary themes and global developments, 25 documents were selected from the refined pool for a more detailed analysis. These studies were chosen for their relevance to the study's objectives and their ability to provide up-to-date insights into the field. This targeted selection ensures that the review remains aligned with the overarching goal of capturing recent advancements and addressing key research questions.

Key Metrics and Analytical Framework

The bibliometric analysis employed several key metrics to evaluate the academic landscape of agricultural extension systems. These metrics include:

1. **Publication Trends:** Analyzing the annual growth rate of publications to understand the expansion of scholarly interest in the field.
2. **Citation Patterns:** Measuring the average citation rate to assess the impact and influence of the literature.
3. **Author Collaboration Networks:** Examining patterns of co-authorship to identify collaborative trends and key contributors to the field.
4. **Thematic Diversity:** Analyzing author keywords to capture the breadth and depth of topics addressed within the literature.

Findings from the Bibliometric Analysis

The analysis revealed a strong annual growth rate of 22.47%

in the number of publications on agricultural extension systems, reflecting significant academic interest and expansion over recent years. This growth underscores the increasing recognition of agricultural extension as a critical area of study, particularly in addressing global challenges such as food security, climate change, and rural development.

A total of 814 authors contributed to the body of work analyzed, with an average of 4.7 authors per document. This metric highlights the predominantly collaborative nature of research in this field, where multi-author studies are the norm. Collaborative efforts often bring together diverse expertise and perspectives, enriching the quality and relevance of the findings. While the majority of the publications were co-authored, nine documents were single-authored, showcasing a balance of individual and team-based contributions within the literature.

The average citation rate of 8.533 per document reflects the impact and scholarly influence of the literature on agricultural extension systems. This citation pattern indicates that the studies analyzed have been widely referenced within the academic community, contributing to the broader discourse on agricultural development and innovation.

International Collaborations and Global Perspective

The bibliometric analysis also highlights the global nature of research on agricultural extension systems. International collaborations accounted for 35.71% of the documents analyzed, showcasing a strong emphasis on cross-border knowledge exchange and collective problem-solving. Such collaborations are particularly important in addressing the diverse challenges faced by agricultural systems worldwide, as they allow for the sharing of best practices, innovative solutions, and context-specific insights.

Thematic Diversity and Author Keywords

The analysis of author keywords revealed a total of 642 unique terms, illustrating the thematic diversity within the literature. These keywords reflect a wide range of topics, including technological innovation, participatory approaches, climate resilience, and policy reform. This diversity underscores the multifaceted nature of agricultural extension systems and their critical role in addressing complex and interrelated issues in agriculture.

Strengths of the Methodology

The systematic approach to data collection, filtering, and analysis ensures that the bibliometric study captures a comprehensive and accurate picture of the academic landscape. By focusing on recent publications (2019-2024), the analysis provides up-to-date insights into the trends and challenges shaping agricultural extension systems. The inclusion of multiple databases and the use of targeted search terms further enhance the robustness of the findings. Moreover, the emphasis on collaborative research and international partnerships highlights the global relevance of agricultural extension systems. This perspective is crucial for understanding the interconnected challenges faced by agricultural systems worldwide and for identifying scalable solutions.

Limitations and Considerations

While the methodology is rigorous, it is important to acknowledge certain limitations. The reliance on

publications in English may exclude relevant studies published in other languages, potentially limiting the global applicability of the findings. Additionally, the focus on journal articles may overlook valuable insights from gray literature, such as reports, policy briefs, and conference proceedings. Future studies could address these limitations by incorporating multilingual and gray literature sources.

This bibliometric analysis provides a comprehensive evaluation of the academic landscape of agricultural extension systems, offering valuable insights into recent trends, challenges, and innovations. By analyzing publication trends, citation patterns, and collaborative networks, the study highlights the growing academic interest and global relevance of this field. The systematic review process ensures that the findings are both comprehensive and focused, aligning closely with the study's objectives. Through this methodology, the study contributes to a deeper understanding of the scholarly trajectory of agricultural extension systems and their critical role in fostering sustainable agricultural development.

Research Questions

- Who are the key stakeholders involved in agricultural extension services and what roles do they play in supporting farmers?
- How effective are the current agricultural extension services in meeting the needs of farmers?
- What are the different extension delivery channels available to farmers and how accessible and utilized are these channels?
- What challenges do farmers face in accessing agricultural extension services, and what difficulties do extension professionals encounter in delivering these services?

Objectives of the Study

- To identify the stakeholders and their role in providing agricultural extension services in Himachal Pradesh (H.P.).
- To evaluate the effectiveness of agricultural extension methods for farmers in H.P.
- To study the accessibility and utilization of different extension delivery channels.
- To identify the challenges faced by farmers and extension professionals in receiving and providing agricultural extension services.

Systematic Literature Review: The 7 Key Steps

A systematic literature review (SLR) is a rigorous and methodical approach to synthesizing existing research on a specific topic. It enables researchers to identify trends, gaps, and critical insights in a structured manner. When applied to the field of agricultural extension systems, an SLR can provide valuable insights into roles, challenges, effectiveness, and innovations within the sector. Below are the seven key steps involved in conducting a systematic literature review:

1. Defining the Scope and Research Questions

The first step in conducting a systematic literature review involves clearly defining the scope and formulating research questions. This step sets the foundation for the entire review process, ensuring that the objectives are precise and the

outcomes are meaningful. In the context of agricultural extension, research questions may include:

- What are the roles of different stakeholders in agricultural extension systems?
- How effective are current agricultural extension services in addressing farmers' needs?
- What are the primary challenges faced by extension services, and what solutions have been proposed?

By establishing well-defined objectives, researchers can ensure that the review remains focused and addresses specific knowledge gaps in the field

2. Developing a Search Strategy

A comprehensive search strategy is critical to retrieving relevant literature on the topic. This involves identifying appropriate academic databases, selecting relevant keywords, and setting parameters for the search process. The most commonly used databases include Scopus, Web of Science, Google Scholar, and institutional repositories.

In the case of agricultural extension systems, keywords like the following may be utilized to refine the search:

- "Extension Services"
- "Farm Advisory Services"
- "Advisory Services"
- "Agricultural Innovation System"
- "Trends," "Status," or "Challenges"

These keywords, along with Boolean operators (e.g., AND, OR), help refine the search and ensure comprehensive coverage of relevant literature. Additionally, researchers must ensure that the search is iterative, continuously refining and adjusting the keywords based on initial results.

3. Setting Inclusion and Exclusion Criteria

Inclusion and exclusion criteria play a pivotal role in ensuring the relevance and quality of the selected studies. These criteria act as filters to narrow down the vast pool of available literature to a manageable and meaningful set of studies.

Inclusion criteria may involve

- Studies published between 2020 and 2024 to ensure relevance to recent trends and developments.
- Peer-reviewed articles to guarantee academic rigor.
- Research focusing specifically on agricultural extension systems, including roles, challenges, and innovations.

Exclusion criteria may include

- Articles written in languages other than English (unless translations are available).
- Studies that are not directly related to agricultural extension, such as those focusing exclusively on unrelated fields.
- Grey literature or unpublished studies unless they offer significant insights.

By adhering to these criteria, researchers can maintain the relevance and integrity of the literature review.

4. Data Collection and Study Selection

Once the search strategy is executed and the

inclusion/exclusion criteria are established, the next step involves systematically collecting and selecting relevant studies. This stage requires careful organization and meticulous screening to ensure that the final selection represents a comprehensive and relevant body of work.

The process typically involves:

- Conducting systematic searches across chosen databases.
- Utilizing reference management tools such as Zotero, EndNote, or Mendeley to organize citations and eliminate duplicate entries.
- Screening titles and abstracts to identify studies that meet the inclusion criteria.
- Conducting a full-text review of shortlisted articles to ensure they are relevant and align with the research objectives.

The study selection process should be documented thoroughly to maintain transparency and reproducibility. This documentation includes details of search queries, databases used, and the rationale for including or excluding specific studies.

5. Data Extraction

Data extraction is a critical step in which key information is systematically collected from each selected study. This involves extracting specific details that align with the research questions and objectives of the review. Key data points to be extracted include:

- **Authorship:** Names of authors and their affiliations.
- **Publication Year:** To identify trends over time.
- **Methodology:** Research methods employed, such as qualitative, quantitative, or mixed methods.
- **Main Findings:** Key results and conclusions drawn from the study.
- **Themes:** Significant themes or concepts identified in the literature.

To organize the extracted data effectively, researchers often use a coding framework or data extraction form. This facilitates the comparison of findings across studies and ensures consistency in data collection.

6. Quality Assessment of Selected Studies

Evaluating the quality and rigor of the selected studies is essential to ensure that the literature review is based on reliable and robust research. Quality assessment involves examining the methodological soundness, relevance, and credibility of each study.

Several quality assessment tools are available for this purpose, including:

- The Critical Appraisal Skills Programme (CASP), which provides checklists for assessing various aspects of a study.
- The Mixed Methods Appraisal Tool (MMAT) for evaluating mixed-methods research.
- The Joanna Briggs Institute (JBI) checklists for systematic reviews and qualitative research.

Key factors to consider during quality assessment include:

- **Study design and methodology:** Is the research design

appropriate for the study objectives?

- **Sample size and representativeness:** Are the findings generalizable to the broader population?
- **Data analysis methods:** Are the methods robust and valid?
- **Relevance of findings:** Do the results contribute to the understanding of agricultural extension systems?

By ensuring that only high-quality studies are included, researchers can enhance the reliability and validity of their review.

7. Data Synthesis and Analysis

The final step in a systematic literature review involves synthesizing and analyzing the extracted data to draw meaningful conclusions. This step requires integrating findings from multiple studies to identify common themes, trends, and gaps in the literature.

Key activities in this step include:

- **Thematic Analysis:** Grouping findings into common themes or categories, such as challenges in extension systems, roles of stakeholders, and emerging technologies.
- **Trend Analysis:** Examining how the focus of research has evolved over time.
- **Gap Identification:** Highlighting areas where further research is needed to address unresolved questions or challenges.

The synthesis process should culminate in a clear and concise summary of the key insights. This summary should address the research questions, highlight the significance of the findings, and provide practical recommendations for policymakers, practitioners, and researchers. Conducting a systematic literature review using these seven steps ensures a structured and comprehensive approach to exploring a research topic. By defining a clear scope, employing a rigorous search strategy, and systematically analyzing the literature, researchers can uncover valuable insights into the agricultural extension landscape. The findings from such a review can inform future research, guide policy development, and improve the effectiveness of extension systems worldwide.

Data Collection and Bibliometric Mapping

In the study titled "Agricultural Extension System," a total of 182 publications were selected, covering the period from 2020 to 2024. Utilizing Scopus as the primary database, this research employed bibliometric mapping techniques to analyze and visualize trends in the field. Zotero software facilitated the creation of detailed bibliometric maps that illustrated publication trends, keyword co-occurrence, citation analysis, and author collaborations. This approach allowed for a comprehensive examination of the research landscape, highlighting areas with significant scholarly activity as well as those requiring further investigation.

Average Citation per Year

The average citation per year serves as a key indicator of the academic impact of studies within the agricultural extension system. High averages signify influential research that is frequently referenced by peers. Factors such as the

popularity of the field, the year of publication, and journal rankings can influence citation rates, providing insights into the ongoing relevance and contributions of various studies.

Annual Scientific Production

Annual scientific production tracks the volume of publications within the agricultural extension discipline each year. A consistent or increasing output signifies a robust research interest and development in the field, while any decline may suggest shifting research priorities. This metric is essential for assessing trends, productivity, and the overall growth of the discipline.

Core Sources

Core sources refer to the main journals, books, and databases that are frequently cited in research related to the agricultural extension system. Identifying these core sources offers insights into authoritative literature, guides future research directions, and helps researchers locate foundational and seminal studies crucial for advancing knowledge in the field.

Word Cloud

A word cloud visually represents the most frequently utilized terms within the selected research corpus, with the size of each term reflecting its frequency of use. This graphical representation provides a quick overview of the dominant topics, themes, and keywords, enabling researchers and readers to easily identify central concepts relevant to the agricultural extension system.

Bibliometric Trends and Insights

Publication Trends

This bar graph illustrates the number of agricultural extension studies published each year. Notably, the highest number of publications occurred in 2020 and 2021, indicating a recent surge in research interest, possibly due to global events influencing agricultural practices. This increase aligns with global trends in agricultural research, driven by heightened awareness of climate change impacts, technological innovations, and a renewed focus on food security. Notable peaks in research output occurred in years following major policy reforms and the introduction of digital agricultural tools.

Influential Authors and Institutions

This horizontal bar graph highlights the authors whose works have received the most citations. Scholars like Babu *et al.* and Hu *et al.* are shown to be particularly influential, contributing significantly to the discourse in agricultural extension. This horizontal bar graph presents the institutions leading in citation impact. The Indian Council for Research on International Economic Relations (ICRIER) and Beijing Agricultural University are among the top contributors, emphasizing the importance of institutional research efforts.

Citation Analysis

This line graph tracks the total number of citations received by publications each year. The peaks in citation counts align with key publication years like 2013, 2018, and 2020, suggesting the enduring influence of research from these periods. Highly cited works tend to address structural challenges in extension systems, such as resource

constraints, top-down information delivery models, and the integration of ICT. Citation networks reveal robust links between studies addressing the effectiveness of extension services and those proposing technological interventions.

- **Recent Trends and Status of Agricultural Extension System**

- Integration of Digital Technologies:** There is a growing trend towards incorporating Information and Communication Technology (ICT) into agricultural extension services. This includes the use of mobile applications, social media, and online platforms to enhance information dissemination and facilitate real-time communication between extension agents and farmers.
 - Emphasis on Sustainability:** Recent studies highlight the critical role of extension services in promoting sustainable agricultural practices. This trend reflects an increasing awareness of environmental challenges, with extension systems focusing on educating farmers about resource-efficient methods and eco-friendly practices to ensure long-term agricultural viability.
 - Participatory and Inclusive Approaches:** There is a shift towards participatory extension models that involve farmers in the decision-making process. This trend aims to ensure that extension services are more responsive to the diverse needs of farmers, particularly in heterogeneous agricultural contexts, as seen in regions like Latin America and Sub-Saharan Africa.
 - Capacity Building for Extension Agents:** Enhancing the skills and knowledge of extension agents remains a priority. Training programs focusing on climate resilience, technology adoption, and effective communication strategies are being developed to empower agents to better serve farmers and adapt to changing agricultural challenges.
- **Increased Collaboration and Partnerships:** There is an emerging trend of collaboration between various stakeholders, including government bodies, non-governmental organizations, and private sector entities. These partnerships aim to create a more integrated and effective extension system, leveraging resources and expertise to address complex agricultural issues more comprehensive.
 - **Number of Publications by Channel**
This bar chart summarizes the number of publications categorized by their respective channels. It illustrates the focus areas within agricultural extension research, showcasing which channels are most active and where there might be gaps in research effort. These visualizations provide a comprehensive overview of the publication landscape within agricultural extension systems, helping to identify trends, quality levels, and areas of focus.

Key Findings

Enhancing Climate Resilience in Extension Services

Antwi-Agyei and Stringer (2021) ^[1] examined the role of extension agents in enhancing climate resilience among farmers in Ghana. Their study highlighted the importance of capacity-building initiatives to empower extension agents with skills in climate communication. By improving the dissemination of climate information, farmers can make

informed decisions to mitigate adverse climate effects, fostering a resilient agricultural community.

Policy Reforms and Operational Shifts

Ashokkumar and Naik (2021) ^[2] analyzed policy reforms in India's extension services, emphasizing the need for structural and operational changes to improve service delivery. They identified staffing shortages, limited reach, and weak integration between research and extension as critical gaps. Decentralization and enhanced partnerships were proposed as strategies to create a demand-driven and efficient extension system.

Similarly, Babu *et al.* (2013) ^[3] conducted a strategic analysis of extension reforms in Indian states like Bihar and Tamil Nadu. They highlighted the importance of decentralized management, stakeholder convergence, and collaborative partnerships to address challenges such as understaffing and limited access.

Challenges in Asian Extension Systems

Baig and Aldosari (2013) ^[4] reviewed agricultural extension systems across Asia, identifying inefficiencies caused by privatization, globalization, and market liberalization. The authors advocated for an integrated approach that combines Information and Communication Technology (ICT) with traditional extension methods. This hybrid system can enhance efficiency, encourage participatory involvement, and address evolving agricultural needs.

Transition to Participatory and Digital Models

Blum *et al.* (2020) ^[14] analyzed the global shift from top-down extension models to participatory systems that leverage digital tools. Their study recommended continued investment in ICT and participatory frameworks to make extension services more adaptable and inclusive.

Chowdary *et al.* (2024) ^[11] highlighted the impact of social media on agricultural extension in India. Platforms like WhatsApp and Facebook have become essential for real-time information sharing and farmer engagement. The study recommended training extension agents in social media use to maximize its potential.

Addressing Food Security and Inclusivity

Camillone *et al.* (2020) ^[7] emphasized the role of Nigeria's extension services in supporting household food security. They argued for prioritizing vulnerable, food-insecure households and recommended improved collaboration between researchers, extension agents, and farmers.

Sahu *et al.* (2023) ^[5] reviewed how extension services contribute to sustainable agricultural practices. By promoting resource efficiency and eco-friendly methods, extension systems can support global sustainability goals. The study recommended prioritizing education on sustainable practices.

Comparative Models and Decentralization

Davidson and Ahmad (2002) ^[8] compared public and private extension models in Pakistan. While private services are more efficient, public systems have broader coverage. The authors suggested a hybrid approach to balance efficiency and inclusivity.

Diab *et al.* (2020) ^[10] examined Egypt's centralized

extension system and proposed decentralized frameworks to improve responsiveness and adaptability. Empowering local extension agents with decision-making authority can enhance service quality and farmer satisfaction.

Technology and Farmer Preferences

Dhehibi *et al.* (2020) ^[9] explored farmer preferences for technology transfer in Tunisia. They found that farmers prioritize affordable and practical technologies tailored to local conditions. The study recommended aligning technology transfer efforts with these preferences to improve adoption rates.

Gao *et al.* (2020) ^[12] examined technology adoption in Chinese extension services. Their findings indicated that farmer-centered approaches and locally relevant technologies significantly boost adoption rates. Continuous evaluation of extension methods is essential to meet evolving farmer needs.

Regional Insights and Innovations

Gatdet (2022) ^[13] evaluated Ethiopian extension services using a mixed-methods approach. The study highlighted gaps in addressing social and economic needs and recommended a blend of quantitative and qualitative methods for comprehensive evaluation.

Getahun and Milkias (2021) ^[16] reviewed the cluster farming model in Ethiopia. This approach promotes collective action, resource sharing, and improved market access. The authors suggested that the cluster model is a scalable strategy for enhancing productivity and efficiency.

Pluralistic and Participatory Systems

Laurens *et al.* analyzed pluralistic extension systems in Latin America, focusing on the coexistence of diverse advisory providers. They emphasized the need for adaptability and alignment with heterogeneous farmer needs. Participatory approaches were identified as key to improving service delivery.

Mukherjee and Modak (2022) ^[24] reviewed paradigms in Indian agricultural extension, highlighting the potential of digital and community-based models. These emerging paradigms can make extension systems more adaptable and participatory.

Neza *et al.* (2021) ^[22] examined the Twigire Muhinzi program in Rwanda, a farmer field school model that emphasizes peer-to-peer learning. The study recommended expanding this approach to strengthen agricultural knowledge exchange.

Role of Private Sector and Media

Nwafor *et al.* (2021) ^[23] explored private sector involvement in Sub-Saharan Africa's extension services. They found that private advisory services complement public systems by providing specialized support. Stronger collaboration between public and private sectors can create a comprehensive extension system.

Yusuf *et al.* (2022) ^[6] analyzed the role of media in agricultural extension during the COVID-19 pandemic in South Africa. Alternative media channels like radio and online platforms were crucial for information dissemination. The study recommended integrating media into extension strategies to enhance outreach, especially in crisis situations.

Historical and Policy Perspectives

Hu *et al.* (2018) ^[20] traced the evolution of Chinese extension services from state-controlled models to market-oriented, participatory approaches. They recommended further reforms to strengthen the market-driven model while supporting smallholder farmers. Karim and Noman (2018) ^[21] analyzed agricultural extension policies in Bangladesh. They identified gaps in policy implementation and suggested stronger coordination among stakeholders to enhance the system's responsiveness and impact.

Synthesis and Recommendations

The literature reveals a dynamic and multifaceted landscape of agricultural extension systems, emphasizing the necessity for adaptability, inclusivity, and responsiveness. Common challenges include inadequate staffing, limited reach, and weak integration of research with extension efforts. Capacity building for extension agents emerges as a critical factor in improving service delivery and fostering climate resilience.

The integration of ICT with traditional methods is a recurring theme, offering potential for enhanced efficiency and farmer engagement. However, addressing digital literacy and infrastructure gaps is essential for successful implementation. Decentralization and participatory approaches are also widely recommended to empower local agents and create responsive systems.

Pluralistic extension systems, as seen in Latin America, highlight the importance of aligning services with diverse farmer needs. Collaborative efforts among stakeholders, including public and private sectors, are crucial for creating demand-driven and efficient extension systems. Additionally, tailored technology transfer and sustainable practices are essential for addressing regional agricultural challenges.

Recommendations

1. **Policy Reforms:** Simplify bureaucratic processes and increase funding for extension activities to enhance service delivery.
2. **Capacity Building:** Expand training programs for extension professionals and empower farmers with modern agricultural knowledge.
3. **ICT Integration:** Invest in digital infrastructure and training programs to maximize the benefits of e-extension. Tailored solutions should address literacy and geographic challenges.
4. **Diversified Services:** Extend services to include allied sectors like livestock and horticulture to support diversified livelihoods.

Conclusion

The review of agricultural extension systems underscores significant progress in research and practice while highlighting persistent challenges. Digital advancements and participatory approaches offer promising solutions, but structural barriers such as resource limitations and policy inefficiencies remain. Addressing these issues requires concerted efforts from all stakeholders to create inclusive and sustainable systems.

By prioritizing collaboration, capacity building, and

technological integration, extension systems can better meet the evolving needs of diverse farming communities. These efforts will not only enhance agricultural productivity but also contribute to broader goals of sustainability and food security in an increasingly complex global agricultural landscape.

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