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EVALUATION APPROACHES AND RESEARCH TRENDS IN OPEN AND DISTANCE AGRICULTURAL EDUCATION: A PRISMA-BASED SYSTEMATIC AND BIBLIOMETRIC REVIEW

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Abstract
This study provides a comprehensive synthesis of research regarding the evaluation of open and distance learning (ODL) in agricultural education through systematic literature review and bibliometric analysis. The results show an upward trend in annual scientific production, with a rise after 2020, reflecting the rapid expansion of digital learning during the COVID-19 period. Bibliometric data shows that India leads in total citations, followed by Australia and the United States while Mauritius, Singapore and Brazil have high average citation impact, showing important contributions despite the lower output. Major publication sources include interdisciplinary journals such as Sustainability (Switzerland), HortTechnology and IEEE Access indicating the convergence of agriculture, education and technology. The analysis of country collaboration shows that the US, India, China and Australia are the main players in a semi-centralized network with limited participation from developing regions. Keyword co-occurrence and thematic mapping show important themes like e-learning, capacity building, agricultural extension and digital learning systems, as well as new areas like artificial intelligence and evaluation linked to sustainability. Methodologically, survey-based designs predominate; however, there is a gradual transition towards experimental, mixed-method and econometric approaches underpinned by theory-driven models. Evaluation indicators mainly focus on learning outcomes, behavioural adoption, institutional support and satisfaction while engagement, skill development and course design remain underrepresented. Key evaluation outcomes indicate that ODL improves accessibility, flexibility and knowledge acquisition for farmers and learners; however, the future research should focus on performance-based tools such as rubrics, simulations, field assessment protocols, competency based, multi-tiered and impact-focused evaluation frameworks in agricultural education.

Keywords: Agricultural education; Bibliometric analysis; Evaluation indicators; Learning outcomes; Open and distance learning; Systematic literature review.

1. INTRODUCTION

The rapid advancement of digital technologies has significantly transformed teaching and learning processes across higher education by enabling flexible access to learning resources beyond the constraints of time and place (Fareen, 2022). Open and distance learning (ODL) has expanded globally as institutions increasingly integrate learning management systems, open educational resources (OER), mobile learning and massive open online courses (MOOCs) into mainstream teaching and training (Bozkurt et al., 2015; UNESCO, 2020). In agricultural education, these modes of delivery hold particular relevance because they can enhance access to knowledge, strengthen extension-linked learning and support skill development for students and farming communities dispersed across rural and remote contexts (Stone et al., 2012).

The importance of ODL became especially evident during the COVID-19 pandemic, when educational institutions worldwide shifted abruptly from classroom-based teaching to emergency remote education (Bakar et al., 2022). While this accelerated innovation in digital pedagogy, it also exposed structural constraints such as unequal access to devices, limited internet connectivity, insufficient institutional support and gaps in digital competence among learners and instructors (Hodges et al., 2020). These constraints are particularly critical in disciplines such as agriculture where learning outcomes often require hands-on practice, field-based activities and competency development that may be difficult to fully replicate in purely online formats (Winder et al., 2018; Jeannette & Meyer, 2002).

Given these contextual challenges, evaluation research is essential for determining whether open distance learning interventions achieve their intended outcomes (Ahmad & Zainol, 2026). Evaluation helps move beyond implementation and participation statistics by systematically assessing effectiveness across multiple levels, including learner satisfaction and engagement, knowledge and skill gains, behavioural change and longer-term impacts. Established models such as Kirkpatrick's training evaluation framework and the Community of Inquiry model have guided evaluation studies by offering structured dimensions for measuring learning processes and outcomes (Kirkpatrick & Kirkpatrick, 2006). Similarly, technology acceptance frameworks such as the Technology Acceptance Model (TAM) remain influential for explaining learner and teacher adoption of educational technologies through constructs such as perceived usefulness, perceived ease of use and behavioural intention (Davis, 1989).

At the same time, digital education interventions in agriculture operate within complex socio-technical systems shaped by infrastructure, institutional readiness, learner characteristics and socio-economic context (Malik & Bhakhar, 2025). Hence, evaluation studies must consider both the enabling conditions and barriers that influence learning effectiveness, particularly for populations facing digital inequality. In systematic reviews, combining bibliometric analysis with evidence synthesis has become increasingly valuable for mapping publication trends, identifying influential contributions and summarising methodological patterns, indicator domains and knowledge gaps within a research field (Aria & Cuccurullo, 2017; Donthu et al., 2021). Such integrated approaches are particularly useful in emerging and interdisciplinary domains such as evaluation studies of ODL interventions in agricultural education.

Therefore, the present study aims to synthesise and map the research landscape on the evaluation of open and distance learning interventions in agricultural education using an integrated systematic literature review (SLR) and bibliometric analysis approach. Specifically, this review evaluates publication patterns and research productivity while synthesising dominant evaluation methodologies, indicators and findings reported across studies. The study is expected to provide evidence-based insights to strengthen evaluation practices and support more effective and equitable implementation of ODL interventions in agricultural education systems with the following objectives,

1. To examine the publication trends and key contributors in evaluation research on open and distance learning in agricultural education.
2. To identify the research designs, methods and evaluation indicators used in studies on open and distance learning interventions in agricultural education.
3. To identify key gaps in existing evaluation practices and derive actionable implications for strengthening evaluation frameworks, policy and practice in open and distance agricultural education.

2. METHODOLOGY

A systematic literature review (SLR) combined with bibliometric analysis was adopted to synthesize and map the research landscape on the Evaluation of open and distance learning (ODL) interventions in agricultural education. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparent identification, screening, eligibility and inclusion of relevant studies which is given in Fig. 1.

2.1. Document search and article screening

In the first stage, a comprehensive literature search was conducted in the Scopus database using a structured search string related to evaluation of open and distance learning in agriculture as shown in Table. 1. The initial database search retrieved a total of 836 records and after applying predefined inclusion and exclusion criteria as shown in Table. 2 such as document type, source type, language, publication stage, access type and time span, 248 records were retained for screening. After screening by reading the title and abstract, 150

records were retained. Duplicate articles were removed (n= 9) and the remaining records were assessed based on relevance to the objectives, resulting in 141 studies included for bibliometric analysis and to assess the evaluation indicators, methodologies and outcomes.

Table. 1. Combination of Keywords used and total number of articles

Database	Search terms/ Keywords	Number of articles
Scopus	("distance learning" OR "online learning" OR "open and distance learning" OR e-learning OR ODL) AND (agricultur* OR "agricultural education" OR extension OR farming) AND (evaluat* OR effectiv* OR impact* OR outcome*)	836

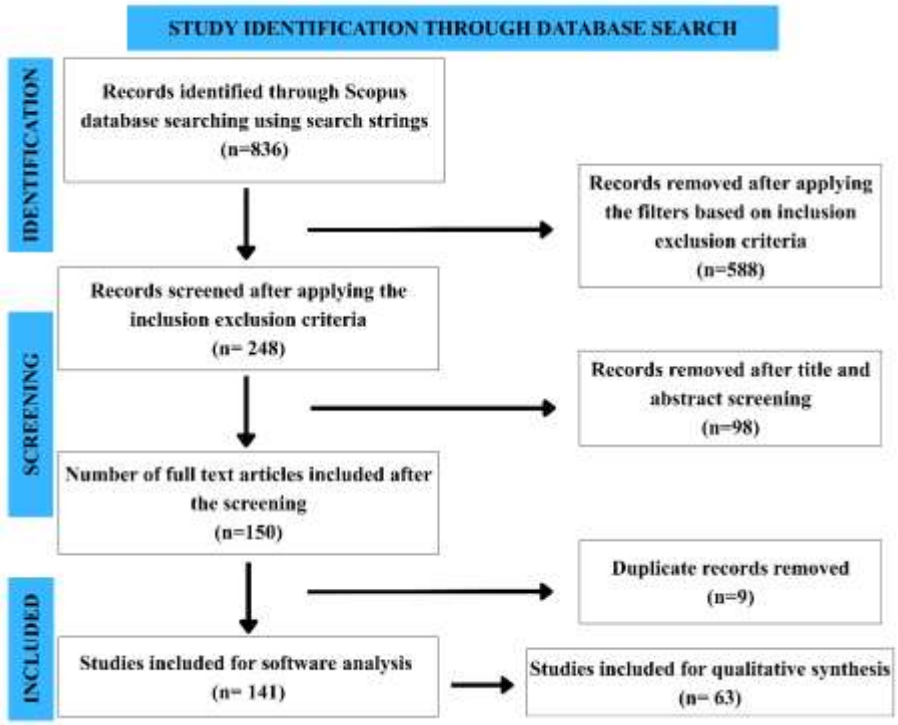
Table. 2. Inclusion and exclusion criteria for the systematic review of literature.

CRITERIA	INCLUSION	EXCLUSION
Literature type	Research article	Review papers, conference paper, book chapters and series
Source type	Journal	Trade journal
Publication stage	Final	Press
Access type	Open source	Restricted access
Subject area	Agricultural and Biological sciences, Social sciences and Computer sciences	Others
Language	English	Non-English
Timeline	2000-2025	<2000

2.2. Method of data analysis

Bibliometric analysis was conducted using the Bibliometric package (Biblioshiny interface) in R, which facilitated performance analysis and science mapping. Key bibliometric indicators such as annual publication trends, most productive journals and country-wise contributions were analysed. Additionally, VOS viewer software was employed to visualize and interpret scientific networks like keyword co-occurrence enabling the identification of dominant research themes and intellectual structure of the field. The combined use of systematic review procedures and bibliometric visualization tools provided a robust framework to map research evolution, methodological trends and evaluation dimensions of ODL interventions in agricultural education.

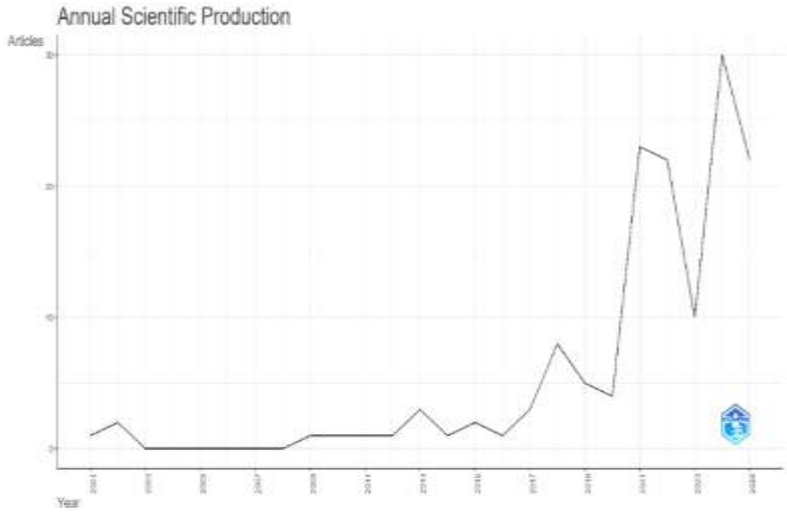
Fig. 1. PRISMA chart showing the article screening process.



3. RESULTS

3.1. Annual scientific production of articles related to evaluation of open and distance learning interventions in agriculture

Fig. 2. Annual scientific production of articles



The annual scientific production trend in Fig.2. indicates that research on the evaluation of open distance learning (ODL) interventions in agricultural education has evolved gradually over time, with a pronounced increase in recent years. During the early period (2001–2008), publication output was minimal, reflecting limited adoption of open and distance learning approaches and a predominant reliance on conventional face-to-face instructional methods in agricultural education. A modest but steady growth is observed between 2009 and 2016, corresponding to the initial integration of e-learning and distance education tools and the emergence of exploratory evaluation studies. From 2017 onwards, the volume of publications increases more

noticeably, suggesting enhanced digital infrastructure, institutional support and growing research interest in evaluating technology-enabled learning. A sharp surge in scientific output is evident from 2020, coinciding with the COVID-19 pandemic, which accelerated the adoption of open distance learning and intensified the need to assess their effectiveness, accessibility and educational outcomes. Although minor fluctuations are observed in the most recent years, the overall trend remains substantially higher than in earlier periods, indicating that the evaluation of ODL interventions in agricultural education has transitioned from an emerging area to a well-established and rapidly expanding field of research.

3.2. Most relevant sources of journals

Table. 3. Most relevant sources of journals related to ODL in Agricultural Education.

Sources	Articles
SUSTAINABILITY (SWITZERLAND)	8
HORTTECHNOLOGY	6
IEEE ACCESS	5
ASIAN ASSOCIATION OF OPEN UNIVERSITIES JOURNAL	4
INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS	4
OPEN PRAXIS	4
AGRICULTURE (SWITZERLAND)	3
COMPUTERS AND ELECTRONICS IN AGRICULTURE	3
INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTRIBUTED LEARNING	3

Table. 3 shows the analysis of most relevant sources reveals that research on the evaluation of open distance learning (ODL) interventions in agricultural education is published across a diverse set of interdisciplinary journals, reflecting the multifaceted nature of the field. Sustainability (Switzerland) emerges as the most productive source with eight articles, indicating a strong emphasis on evaluating ODL interventions in relation to sustainability, inclusive education and long-term capacity building in agricultural systems. HortTechnology, contributing six articles, highlights the evaluation frameworks in horticultural education, as well as the growing use of digital pedagogies in applied agricultural sciences. The presence of IEEE Access and the International Journal of Advanced Computer Science and Applications underscore the role of educational technologies, digital platforms and analytics-driven evaluation approaches in ODL research. Journals such as the Asian Association of Open Universities Journal, Open Praxis and the International Review of Research in Open and Distributed Learning reflect a strong theoretical and policy-oriented focus on open and distance education systems, particularly in developing and Asian contexts. Additionally, the inclusion of agriculture-specific journals such as Agriculture (Switzerland) and Computers and Electronics in Agriculture indicates increasing integration of digital learning evaluation within core agricultural research outlets. Overall, the distribution of sources suggests that evaluation research in ODL for agricultural education is highly interdisciplinary, bridging sustainability, education, agriculture and information technology and reinforcing the relevance of this topic across multiple scholarly domains**.**

3.3. Most cited countries in the world

Table. 4. Total and average article citations of leading countries in open and distance learning (ODL) research in agricultural education.

Country	Total Citations	Average Article Citations
INDIA	782	71.10
AUSTRALIA	292	36.50
MAURITIUS	264	264.00
USA	229	11.40

ITALY	181	30.20
CHINA	119	13.20
SINGAPORE	85	85.00
BRAZIL	83	83.00
GERMANY	81	20.20
SPAIN	76	38.00

The bibliometric analysis of the most cited nations in the field of open and distance learning (ODL) in agricultural education in Table. 4 demonstrates the evident difference between the productivity of research and the impact of citations. India tops the list of the citations (782) meaning that it performs the bigger contribution and has a lot of research in this area. Australia (292) and the United States (229) also have high counts of citations indicating that they are actively engaged, but the relatively small average number of citations per article in the United States (11.40) suggests that there is high production but moderate influence of the independent studies. Conversely, Mauritius (264.00), Singapore (85.00) and Brazil (83.00) appear to have a significantly higher average number of citations of articles even though the volume of publications is lower, reflecting the existence of fewer but more impactful studies. European nations such as Italy (30.20), Spain (38.00) and Germany (20.20) have a balanced performance with moderate total citations and steady average impact, which demonstrates the steady research quality. China, having 119 overall citations and a smaller average (13.20) indicates increasing involvement but a relative lack of impact per publication. In general, the results indicate that in aggregate, small countries are making an impact in agricultural ODL research, although countries such as India are leading in terms of research volume with high-impact publications, which highlights a two-fold trend of quantity and quality in agricultural ODL research.

3.4. Countries collaboration world map

Fig.3. Global country collaboration network in research on evaluation of open and distance learning (ODL) in agricultural education.

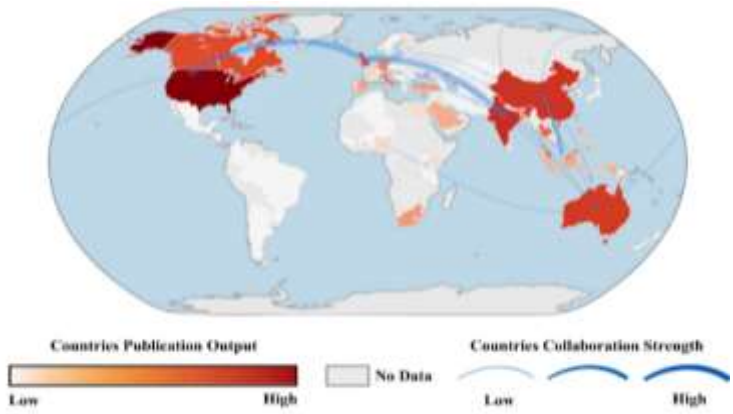


Fig.3, country collaboration network map illustrates the worldwide spread and interconnectedness of research in open and distance learning (ODL) in agricultural education with a moderately collaborative but highly concentrated structure. The main hub with the most research output is the United States that connects the areas of Europe, Asia and Oceania. Other significant players such as India, China, Australia and the United Kingdom are also highly research active, especially in domains such as digital extension, e-learning and ICT-based agricultural training, and are involved in significant international partnerships. The trend indicates a high level of North-South and East-West connections with partnerships being bilateral and focus on major countries instead of multilateral connections. Conversely, some areas like Africa, Latin America and some parts of Southeast Asia have seen minimal involvement, meaning that they have varied digital infrastructure, research capacity and institutional support to the agricultural ODL. Overall, the semi-centralized network suggests that knowledge production is dominated by a few countries, underscoring the need for more

inclusive collaborations, especially South-South partnerships, to ensure context-relevant and equitable advancement of ODL in agricultural education.

3.5. Thematic map on evaluation studies related to open and distance learning in Agriculture

Fig. 4. Thematic map on evaluation studies related to open and distance learning in Agricultural Education

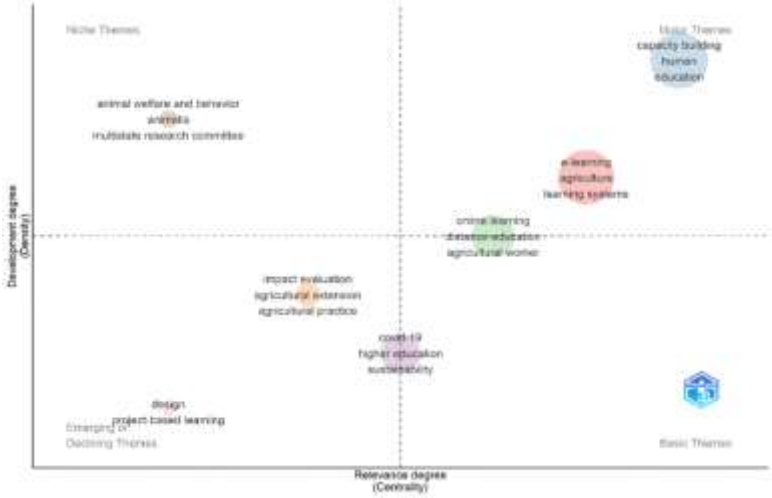


Fig. 4. illustrates the conceptual structure and maturity of research on the evaluation of open distance learning (ODL) interventions in agricultural education by positioning themes according to their relevance (centrality) and development (density). Motor themes such as capacity building, human, education and the closely linked cluster of e-learning, agriculture and learning systems occupy the upper-right quadrant, indicating that technology-enabled learning systems and human capacity development are well-developed and drive the intellectual core of the field. Basic themes, including online learning, distance education and agricultural worker are highly central but less densely developed, suggesting their foundational role as common conceptual anchors for evaluation studies. Niche themes such as animal welfare and behaviour and multistate research committee are internally mature but weakly connected to the broader literature, reflecting specialized research streams. In contrast, emerging or declining themes like design and project-based learning indicate areas with limited current attention but potential for future exploration. Themes located near the centre, including impact evaluation, agricultural extension, COVID-19, higher education and sustainability, act as bridging concepts, highlighting a gradual shift towards integrative evaluation approaches that link digital learning effectiveness with extension outcomes and broader educational and sustainability goals.

3.6. Keyword co-occurrence in the evaluation studies of open and distance learning in Agricultural Education.

Fig. 5. Keyword co-occurrence network

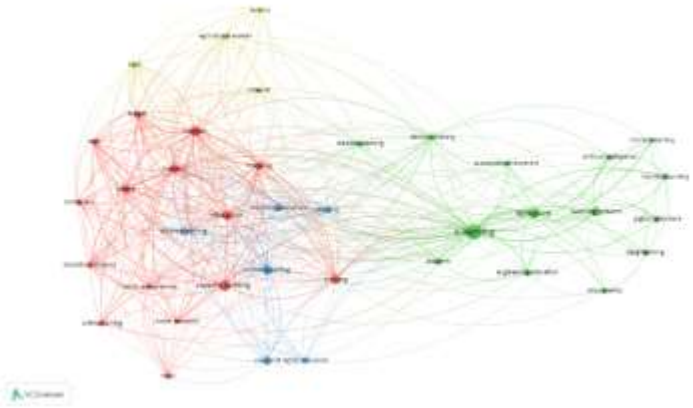


Fig. 5. reveals the intellectual structure and thematic interlinkages of research on the evaluation of open distance learning (ODL) interventions in agricultural education. The network is organized into distinct yet interconnected clusters indicating the multidisciplinary nature of the field. A prominent cluster centered on education, distance education, online learning, learning and capacity building reflects the core pedagogical and evaluative focus, emphasizing learner outcomes, instructional processes and human-centred evaluation. Closely connected to this is a cluster dominated by e-learning, agriculture, learning systems and students, highlighting the integration of digital learning platforms within agricultural education contexts. A technologically oriented cluster featuring artificial intelligence, machine learning, deep learning, digital agriculture and virtual reality signifies an emerging methodological shift toward advanced technologies and data-driven evaluation of learning systems. Another cluster associated with farmers, agricultural worker, adult and internet underscores the application of ODL interventions beyond formal education to extension-oriented and lifelong learning contexts. Bridging keywords such as blended learning, training, decision making and sustainable development connect these clusters, indicating growing interest in hybrid delivery models and impact-oriented evaluation. Overall, the dense interconnections and central positioning of core educational and e-learning keywords suggest a maturing and integrative research domain, where pedagogical evaluation, agricultural applications and emerging digital technologies increasingly converge.

4. FINDINGS AND DISCUSSION

4.1. Evaluation research designs

Table. 5. Distribution of evaluation study designs among included studies (n = 63).

Design category	Frequency	Percentage (%)
Survey / cross-sectional	18	28.6
Experimental / quasi-experimental	11	17.5
Qualitative / case analysis	11	17.5
Mixed methods	8	12.7
Econometric / impact evaluation	8	12.7
Conceptual / framework	7	11.1
Total	**63**	**100**

Table. 5 represents that the included studies (n = 63) on evaluation research of open and distance learning interventions in agricultural education are predominantly dominated by survey-based cross-sectional designs (28.6%). However, the presence of experimental/quasi-experimental (17.5%) and qualitative/case-based (17.5%) studies reflect increasing efforts to assess intervention effectiveness and capture context-specific insights. Mixed-methods evaluations (12.7%) and econometric impact evaluations (12.7%) were also evident, suggesting a gradual shift towards integrating multi-source evidence and measuring behavioural and livelihood-level outcomes. Conceptual and framework-based studies (11.1%) contributed to structuring evaluation dimensions and guiding indicator selection.

4.2. Evaluation indicator domains

Indicator domain frequency is counted as occurrences, not papers, because many studies measure more than one domain.

Table. 6. Major evaluation indicator domains assessed in the included studies (n = 63).

Indicator domain	Count (occurrences)	Share (%)
Learning Gain / Performance	16	21.3
Behaviour / Adoption / Impact	14	18.7
Institutional / Infrastructure / Support	14	18.7
Satisfaction / Reaction	14	18.7
Acceptance / Readiness	8	10.7
Engagement / Interaction	7	9.3
Quality / Course Design	5	6.7
Skill / Competency	5	6.7
Total domain occurrences	75	100

Note: Total occurrences exceed the number of studies as several articles measured multiple indicator domains.

With respect to evaluation indicators, Table. 6 shows the included studies have collectively emphasized learning gain/performance outcomes (21.3%), including knowledge improvement, test scores, and academic performance measures. A comparable focus was observed on behavioural and adoption-oriented indicators (18.7%), highlighting a growing interest in evaluating whether learning translates into practice change, technology adoption, productivity gains, or livelihood outcomes. Institutional and infrastructural indicators (18.7%) and satisfaction/reaction measures (18.7%) were also frequently assessed, indicating that access conditions, connectivity, learner support and immediate learner experiences continue to shape the effectiveness of agricultural ODL interventions. In contrast, engagement/interaction indicators (9.3%) and quality/course design measures (6.7%) were less frequently reported, suggesting limited emphasis on systematic evaluation of pedagogical design quality and learner engagement processes. Similarly, skill and competency-focused indicators (6.7%) remained underrepresented, highlighting the need for more competency-based and performance-oriented evaluation frameworks in agricultural education, where practical and applied learning outcomes are critical.

4.3. Evaluation methodologies and analytical approaches

Across the included studies, evaluation methodologies of open and distance learning (ODL) interventions in agricultural education can be synthesized into five major methodological approaches.

4.3.1. Survey-based evaluative approaches

A significant portion of the research employed survey-based evaluative methods, where structured questionnaires were utilized to evaluate farmers and agricultural learners' perceptions, levels of satisfaction, readiness to adopt digital learning platforms and perceived outcomes of ODL programmes (Muthuprasad et al., 2021; Hasan & Mondal, 2019; Ozan & Özarslan, 2025; Shravani et al., 2025; Nivedha et al., 2024; Rajabalee & Santally, 2021; Gong et al., 2025). These investigations generally used Likert-scale measurements along with descriptive or inferential statistical analyses, providing quick insights into user experiences and challenges related to open and distance learning, especially during rapid transitions like the COVID-19 pandemic (Sawarkar et al., 2020; Van Haeften et al., 2021; Gombkoto et al., 2024, Naknat et al., 2025).

4.3.2. Theory-driven models for technology acceptance and readiness

Many studies have utilized theory-driven models such as the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology- Organization-Environment (TOE) framework to examine factors influencing the adoption and continued use of digital learning systems in agricultural education (Sobhani et al., 2025; Ozan & Ozarslan, 2025). In addition, other

important models including the Diffusion of Innovations (DOI) theory, Theory of Planned Behavior (TPB), Social Cognitive Theory (SCT), the DeLone and McLean Information Systems Success Model, the Expectation- Confirmation Model (ECM) and the E-learning Acceptance Model (ELAM) have also been incorporated to strengthen evaluation in ODL contexts. These evaluations typically assess constructs such as perceived usefulness, perceived ease of use, self-efficacy, facilitating conditions, satisfaction and behavioral intention, employing analytical techniques like regression analysis, confirmatory factor analysis and structural equation modeling to enhance the explanatory depth of findings. (Castiblanco et al., 2021, Machingura & Muyavu, 2025).

4.3.3. Experimental and quasi-experimental training evaluation

Experimental and quasi-experimental training evaluation methodologies were widely applied in studies assessing the effectiveness of structured online interventions such as e-learning modules, MOOCs, extension-oriented trainings and blended learning programmes (Winder et al., 2018; Isbrandt et al., 2023; Michaelis et al., 2022; Jeannette & Meyer, 2002; Rieger, 2002; Bello-Bravo et al., 2018). These studies often utilised pre-test/post-test designs and comparative evaluations (e.g., online versus in-person) to measure learning gain, confidence, skill development and retention, providing stronger evidence of intervention effectiveness than perception-only evaluations (Gallo et al., 2024; Alenizi, 2022; Abai & Hamli, 2025; Kumar et al., 2022; Asgar & Satyanarayana, 2021; Manning et al., 2024).

4.3.4. Qualitative and mixed-method evaluation

Qualitative and mixed-method evaluation designs were utilised to capture the contextual realities of programme delivery, learner challenges and implementation constraints within diverse agricultural education settings (Wang & Hanafi, 2024; Loso, 2025; Hot et al., 2025; Sawarkar et al., 2020; Rajabalee & Santally, 2021, Karunanayaka et al., 2013). These studies commonly used interviews, focus group discussions, narrative inquiry and thematic analysis to complement quantitative findings, enabling deeper understanding of institutional barriers, learner diversity, instructor preparedness and the practical limitations of purely online approaches for agriculture-related skills development (Kafile, Ninana & Makhetha-Kosi, 2025; Dong & Albro, 2025; Hadullo et al., 2018; Bezuidenhout, 2018; Grunfeld & Ng, 2013).

4.3.5. Econometric and impact evaluation approaches

An emerging subset of studies applied econometric and impact evaluation approaches to examine the influence of digital learning and information access on measurable outcomes such as agricultural technology adoption, green production behaviour, productivity enhancement, income improvement and employment outcomes. These studies used analytical strategies such as probit/logit models, propensity score matching and other econometric techniques to strengthen causal interpretation, thereby extending evaluation beyond satisfaction and performance to include behavioural and livelihood impacts relevant to the agricultural sector (Guo et al., 2018; Ren et al., 2023; Li et al., 2024; Doyle et al., 2021). Overall, the methodological diversity observed across the reviewed studies reflects a gradual shift from descriptive evaluation towards more robust, theory-informed and outcome-oriented assessment strategies, while also signalling the need for more integrated multi-level evaluation approaches in agricultural ODL implementation (Senevirathne et al., 2022; Fozdar, 2015; Pardue, 2001).

5. KEY EVALUATION OUTCOMES ACROSS THE INCLUDED STUDIES

A synthesis of key evaluation outcomes and representative supporting studies is presented in Table.7, highlighting the dominance of learning gain and behavioural impact measures.

Table. 7. Key evaluation outcomes across the included studies

Key evaluation outcomes (theme)	Summary of evidence across studies	Representative studies
Positive learning outcomes and performance gains	Many interventions reported improved knowledge, academic performance, competence gains, and higher post-training scores, particularly in structured intervention	Winder et al., 2018; Isbrandt et al., 2023; Bello-Bravo et al., 2018; Jeannette & Meyer, 2002; Rieger, 2002; Gallo et al., 2024

	and training settings (pre–post or comparative designs).	
Flexibility and accessibility benefits of ODL	Learners valued convenience, reduced travel time, access to learning resources, and ability to learn from remote locations; these advantages were especially relevant for rural or time-constrained learners.	Muthuprasad et al., 2021; Nivedha et al., 2024; Shravani et al., 2025; Sciarappa et al., 2016; Stone et al., 2012; Calvo et al., 2020; Santos et al., 2025
Infrastructure and institutional constraints	Connectivity limitations, device access barriers, inadequate technical support and varying instructor preparedness consistently influenced satisfaction, engagement and overall effectiveness, particularly in low-resource contexts.	Kafile, Ninana & Makhetha-Kosi, 2025; Hadullo et al., 2018; Bezuidenhout, 2018; Sawarkar et al., 2020; Rajabalee & Santally, 2021; Gombkötő et al., 2024; Wambugu, 2018; Dong & Albro, 2025
Practical skill limitations and need for blended/hybrid modes	Several studies emphasized that agriculture is skill and practice intensive and purely online delivery may be insufficient for hands-on competence development. Hybrid models combining digital learning with practical sessions were commonly recommended.	Jeannette & Meyer, 2002; Sciarappa et al., 2016; Manning et al., 2024; Winder et al., 2018; Yooyativong & Kamyod, 2023; Grunfeld & Ng, 2013
Emerging evidence of behavioural and impact outcomes	A growing subset of studies moved beyond satisfaction/learning to demonstrate behavioural change and impact outcomes such as adoption of improved practices, green behaviour, productivity gains, income improvement and employment outcomes.	Hasan & Mondal, 2019; Guo et al., 2018; Ren et al., 2023; Li et al., 2024; Gong et al., 2025; Nguar & Appolloni, 2025; Calvo et al., 2020

6. IMPLICATIONS FOR EDUCATIONAL EVALUATION: GAPS, FRAMEWORKS AND FUTURE DIRECTIONS

Despite the growing evidence base, the synthesis reveals important methodological and conceptual gaps that require attention in future research. First, the dominance of survey-based cross-sectional evaluations indicates continued reliance on satisfaction and perception measures, which may not adequately capture long-term learning transfer, skill acquisition and field-level impacts (Muthuprasad et al., 2021; Nivedha et al., 2024; Shravani et al., 2025; Gombkötő et al., 2024; Sawarkar et al., 2020). This highlights the need for a shift in evaluation practice towards experimental, longitudinal and mixed-method evaluation designs to strengthen causal interpretation and improve robustness of findings (Winder et al., 2018; Michaelis et al., 2022; Hot et al., 2025; Gallo et al., 2024).

The reviewed studies show notable heterogeneity in evaluation tools and indicators, with many studies relying on locally developed instruments and inconsistent reporting practices limits cross-study comparability and generalisation, particularly when contextual factors (e.g., institutional capacity, learner readiness and infrastructure disparities) differ substantially (Hadullo et al., 2018; Bezuidenhout, 2018; Kafile, Ninana & Makhetha-Kosi, 2025; Senevirathne et al., 2022). This underscores a critical implication to develop standardised, validated and context-sensitive evaluation frameworks that integrate learner, instructor and institutional dimensions relevant to agricultural education and extension systems (Castiblanco et al., 2021; Fozdar, 2015).

Although agriculture is inherently applied and practice-oriented, competency and skill-based assessments were relatively underrepresented compared with knowledge and satisfaction measures. Evaluations that incorporated practical skill measurement or competence development outcomes were comparatively fewer (Winder et al., 2018; Yooyativong & Kamyod, 2023; Michaelis et al., 2022). Future evaluation studies should incorporate performance-based tools such as rubrics, simulations, field assessment protocols and competency frameworks to capture practical learning outcomes more accurately (Manning et al., 2024; Dong & Albro, 2025; Kumar et al., 2022).

Engagement and interaction metrics were evaluated less often, even though they play a crucial role in online learning settings to maintain participation and facilitate in-depth learning. By merging learning analytics, participation metrics and process indicators (such as interaction quality, collaboration, feedback loops and retention trends), we could gain better insights into learning processes and enhance program development (Rajabalee & Santally, 2021; Stone et al., 2012; Van Haeften et al., 2021; Calvo et al., 2020). On an institutional level, learner engagement may be limited by insufficient support and a lack of instructor readiness, underscoring the necessity of creating evaluation frameworks that clearly include process indicators together with outcomes (Bezuidenhout, 2018; Hadullo et al., 2018; Loso, 2025).

While impact evaluation studies are emerging, more evidence is required to establish whether ODL interventions consistently translate into measurable improvements in adoption behaviour, farm performance, sustainability outcomes and livelihood gains across diverse agricultural contexts (Guo et al., 2018; Ren et al., 2023; Li et al., 2024). Future studies should link digital learning interventions with behavioural, productivity and socio-economic outcomes, particularly in low-resource regions where digital inequality may shape intervention effectiveness (Hasan & Mondal, 2019).

In the future, evaluation studies should adopt integrated models that link inputs (readiness and infrastructure), processes (engagement and learning design), outputs (satisfaction and completion), outcomes (learning gains and skill development) and impacts (adoption and livelihood results). These multi-layered evaluation strategies would facilitate stronger evidence generation and assist institutions, extension systems and policymakers in enhancing the effectiveness and equity of open, and distance learning initiatives in agricultural education (Senevirathne et al., 2022; Nguar & Appolloni, 2025; Calvo et al., 2020).

7. CONCLUSION

The systematic and bibliometric review synthesised evidence from studies on the evaluation of open and distance learning interventions in agricultural education. The findings show that evaluation research is dominated by survey-based designs and frequently focuses on learning performance, satisfaction, infrastructure support and behavioural adoption outcomes. While ODL interventions are widely reported to enhance accessibility and improve learning outcomes, persistent barriers such as connectivity limitations, inadequate learner/instructor support and the challenge of assessing practical competencies remain significant. Overall, the evidence supports the effectiveness of ODL when supported through sound instructional design and institutional readiness and highlights the need for future research to adopt more longitudinal, competency-based and impact-oriented evaluation frameworks to strengthen agricultural education outcomes.

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