



Automation in Agriculture Libraries: Trends, Technologies and Future Prospects

**Anuj Yadav ^{a++}, Pratibha Pandey ^{b++*}, Ruchi Singh ^{c#}
and Shrawan Kumar Shrimali ^{a†}**

^a Department of Library and Information Science, MLSU, Udaipur, Rajasthan, India.

^b Department of RMCS, College of Community Science, GBPUAT, Pantnagar, Uttarakhand, India.

^c Department of Human Development and Family Studies, School of Home Science, BBAU, Lucknow, Uttar Pradesh, India.

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ABSTRACT

Agricultural libraries play a vital role in supporting research, education and extension by providing access to reliable information resources. With the rapid growth of information and communication technologies (ICT), automation has become central to modernising these libraries and enhancing their efficiency. This review paper explores the evolution, functions and services of agricultural libraries in the context of automation, highlighting both the opportunities and challenges. It synthesises literature from academic databases, policy documents and case studies to analyse the contributions of automation in cataloguing, digital repositories, resource sharing and information dissemination. Challenges faced without automation, such as manual inefficiencies, limited

⁺⁺ Ph.D. Scholar;

[#] Research Assistant;

[†] Guest Faculty;

^{*}Corresponding author: Email: pratihema2803@gmail.com;

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accessibility and higher operational costs, are also discussed. Furthermore, the review identifies emerging trends, including AI-powered knowledge management, cloud-based systems, IoT-enabled services, voice-assisted retrieval and blockchain for secure information management, that promise to reshape the future of agricultural libraries. The paper emphasises that automation not only improves access and resource management but also strengthens agricultural knowledge networks, supporting farmers, researchers and policymakers alike. Recommendations are provided for policymakers, agricultural library managers, researchers and technology developers to foster sustainable and inclusive automation strategies.

Keywords: Automation; agricultural libraries; digital transformation; knowledge management; library services.

1. INTRODUCTION

1.1 Definition and Concept of Automation in Libraries

Libraries and information specialists are a basic and crucial element in educational and research processes. They are forced to continuously adjust and transform to meet user expectations, maintain scholarly communication, and keep up with the continuous developments in institutions for higher education (Ivanova, 2024). Libraries are known for using Information and Communication Technology (ICT) both for automation of their routine activities as well as for providing search services to the users. Computers are increasingly used in libraries both for internal operations as well as for accessing information that is available in the four walls of the library (Jena, 2025). The application of computers avoids repetitive jobs and saves labour and time for both users as well as outside the library staff. Computers are not only used as a data processing tool, but also for information storage, access and retrieval.

As per the Encyclopedia of Library and Information Science, "automation is the technology concerned with the design and development of processes and systems that minimise the necessity of human intervention in operation" (Kent, 1977).

According to the Oxford English Dictionary, automation means "application of automatic control to any branch of industry or science, by extension, the use of electronic or mechanical devices to replace human labour".

1.2 Role of Libraries in Agricultural Research, Extension and Education

"Development of an integrated information system and databases through an electronic network linking Indian National Agricultural Research System (INARS) institutions to support

planning and management of agricultural research and education was recognised by the ICAR review committee as early as 1988, and development of a computerised satellite-based information network, ICARNET was recommended. In 1991, the development of a computer-based network began. Agricultural Research Information System (ARIS) was initiated by ICAR. In 1997 National Agriculture Technology Project (NATP), funded by the World Bank, was launched with the aim of strengthening the country's agriculture research system. It has been implemented in close cooperation with ICAR institutions, SAUs and other organisations. Information System Development (ISD) was the sub-component of NATP. It was supporting the Agricultural Research Information System (ARIS) and library improvement, and networking. Efforts have been made for automation, networking and strengthening of agriculture libraries under library improvement and networking" (Shilpa et al., 2013).

1.3 Importance of Automation in Agricultural Libraries for Knowledge Dissemination

"From ancient times, the library's existence has been proven in many texts, though it had a different identity. But the aim of the library remains the same as to collect, organise, store and disseminate the required information to the right users" (Takher, 2024). "India is considered the mother of traditional knowledge in each discipline, like Ayurveda, yoga, food culture, literature and agriculture". (Mohanty et al., 2025).

"In view of the enormous capacity of data storage, quick processing, access, retrieval, and dissemination of information, libraries and information centres of our country have started using computers for these activities. In the beginning, computers were used by big academic institutions like DTs, IIMs, and other

national institutions like CSIR, INSDOC, NASSDOC, DRTC, DRDO, BARC and other institutions of higher learning of national importance” (Muniraja, 2021). “Moreover, the rapid growth and adoption of IoT technology are predicted to expand to 75 billion by 2025. IoT devices provide significant benefits in various domains, including university education, where they enhance smart classrooms and student engagement” (Țălu, 2025).

The main purpose of library automation is to free the librarians and library staff and to allow them to contribute more meaningfully to the spread of knowledge and Information. “Library automation can be defined as the use of computers and networking technologies in the library. Use of computer technology for library keeping operations, such as administrative work, acquisition, cataloguing, circulation, serial control, OPAC, etc. known as library automation” (Kumbhar, 2015).

1.4 Objectives and Scope of the Review

The primary objective of this review is to examine the current status, challenges and emerging trends in the automation of agricultural libraries. Specifically, the paper aims to:

- Identify and synthesise existing literature on automation technologies adopted in agricultural libraries at national and global levels.
- Analyse the functions and services of agricultural libraries that have been transformed through automation, including cataloguing, circulation, digital repositories, resource sharing and information literacy services.
- Explore challenges and limitations faced by agricultural libraries in the absence of automation, particularly in rural and resource-constrained contexts.
- Highlight future trends and technologies, such as AI, cloud-based systems, IoT integration, voice-assisted retrieval and blockchain, and assess their relevance for agricultural knowledge management.
- Provide policy and practice recommendations for stakeholders, including policymakers, agricultural library managers, researchers and technology developers.

The scope of this review encompasses scholarly articles, institutional reports, policy documents

and case studies that address the application of automation, ICT and digital technologies in agricultural libraries. The focus is on the role of automation in enhancing knowledge dissemination, supporting agricultural research and education, improving user access and promoting collaborative information services.

2. METHODOLOGY

This review adopted a systematic approach to identify, analyse and synthesise literature on automation in agricultural libraries, focusing on trends, technologies, challenges and future prospects.

2.1 Criteria for Selecting Literature

Relevant scholarly articles, conference proceedings, reports and institutional documents were identified through electronic databases such as Scopus, Web of Science, Google Scholar, AGRIS, Krishikosh, INFLIBNET and FAO repositories. Searches were conducted using combinations of the following keywords: library automation, agricultural libraries, ICT in agriculture libraries, digital repositories in agriculture, AI in libraries, cloud-based library systems, blockchain in library science, IoT and agricultural information services and knowledge management in agriculture.

2.2 Time Frame of Literature Reviewed

The review primarily covered literature published between 2010 and 2025, a period that reflects rapid advances in digital transformation, automation and smart agriculture initiatives. Earlier foundational works were also included (e.g., Kent, 1977; IFLA reports from the 1990s) to provide historical context for automation concepts and definitions.

2.3 Inclusion Criteria

- Peer-reviewed journal articles, conference papers, books, government and institutional reports focusing on library automation, ICT adoption and digital transformation in agricultural or academic libraries.
- Studies explicitly addressing emerging technologies (AI, IoT, blockchain, cloud computing) relevant to libraries.
- Literature providing best practices or impact evaluations in agricultural library contexts.

2.4 Analytical Approach

A thematic analysis approach was adopted to synthesise findings across the selected literature. Sources were grouped into categories based on:

1. Historical foundations of library automation
2. Current practices in agricultural library automation
3. Challenges faced without automation
4. Technologies enabling automation
5. Future trends (AI, IoT, blockchain, cloud systems, voice-assisted tools)

Where relevant, a chronological review was also used to trace the evolution of automation in agricultural libraries from early digitisation projects (e.g., ARIS, CeRA) to current AI-driven initiatives. The findings were critically compared to highlight gaps, opportunities and best practices for advancing automation in agricultural information systems.

3. RESULTS AND DISCUSSION

3.1 Overview of Agricultural Libraries

"Agriculture is India's largest livelihood provider, and traditional knowledge is passed down through generations. Libraries are crucial in supporting agricultural research and education, providing open access to resources. Information centres like CeRA, AGRIS, ICAR and FAO Institutional Repository of Agriculture – KrishiKosh promote the use of agricultural resources. The study reviews articles and websites related to agricultural resources and research, examining their structure, audience, collection, search techniques and use" (Mohanty *et al.*, 2025).

"Library associations play an important role in the development of libraries. It provides a forum for professionals to share their experiences and to suggest new measures for development at the national level. Associations can also play a vital role in conducting training and short courses for library professionals in information technology and other technological developments, besides providing informal training through conducting seminars, workshops and conferences" (Shilpa *et al.*, 2013).

3.2 Information Access and Management

The types of innovative information access and management are as follows:

- **Consortiums for e-Resources in Agriculture (CeRA):** The Consortium for e-Resources in Agriculture, popularly known as CeRA, facilitates online access based on the static IP address to more than 3400 journals in agriculture. The allied sciences to all researchers comprising scientists, teachers, faculty, research fellows and students in the National Agricultural Research System (NARES) through IP authentication.
- **Indian Digital Ensemble of Agricultural Libraries (IDEAL):** The Indian National Agricultural Research and Education System's (NARES) agricultural libraries can use IDEAL as a ready platform to implement an Integrated Library Management System for daily operations of all library functions. It is a software platform designed on the Software as a Service (SaaS) concept to provide a hassle-free, ready-to-use, worldwide standards-based platform for sharing library holdings through the AgriCat union catalogue.
- **OPAC and Web OPAC:** "OPAC means Online Public Access Catalogue. It is a database of a library or group of libraries. Any library user can access such a database to know the study materials (books, CDs, DVDs, cassettes, videotapes, articles, etc.) available in the library or libraries concerned. The concept of Web OPACs is relatively new. It acts as a portal to the resources owned by the individual library and the holdings of other collaborating libraries that do not have a local collection but have access to resources at the regional, national and worldwide levels. It allows users to interact with documents stored on computers worldwide and makes catalogue data, such as bibliographic entries, more accessible. Library users can also use Web-OPAC from anywhere. Such innovative service saves users time searching for their required study materials stored in various libraries" (Shilpa *et al.*, 2013).
- **Krishikosh Repository:** "Krishikosh is an institutional repository developed under the E-Granth subproject of the National Agriculture Innovation Project, funded by ICAR and governed by IARI, New Delhi, NAIP (National Agriculture Innovation Project). Digitisation and creation of an open-access Institutional Repository using Krishikosh. Krishikosh is a digital

repository of accumulated knowledge in agriculture and allied sciences, with a collection of old and valuable books, old journals, thesis, research articles, popular articles, monographs, catalogs, conference proceedings, success stories, case studies, annual reports, newsletters, pamphlets, brochures, bulletins and other grey types of literature scattered across the country in various ICAR Research Institutions and State Agricultural Universities (SAUs)" (Shilpa et al., 2013).

- **Libraries with RFID Systems:** "Radio-Frequency Identification (RFID) is a wireless system that uses electromagnetic fields. This system automatically identifies and tracks the chip attached to the books and materials of the library. It is one of the self-service schemes where a library user can take their required books. The identity of books, the name of the user and the date of issuing the book are automatically recorded in the e-register of the library. The library using an RFID system does not allow the users to take any book or material unless a proper procedure of recording the issued books and their use is followed, which ultimately avoids the risk of theft" (Singh, 2021)

3.3 Functions and Services Provided by Libraries

- **Collection development (selection and acquisition):** Libraries identify, select and acquire relevant print and digital materials (books, journals, e-resources) to meet the information needs of their users and parent institutions (INFLIBNET).
- **Organisation, cataloguing and classification:** Materials are catalogued and classified so that users (and library staff) can find, retrieve and use resources quickly (OPACs, metadata, subject access) (INFLIBNET).
- **Reference and information services:** Librarians provide expert assistance in locating, evaluating and interpreting information in person, by phone, e-mail or online chat and help users with effective search strategies (Jharotia & Mishra, 2024).
- **Circulation and lending services:** Controlled lending (borrowing/returning) and related borrower services that ensure equitable access to physical and (where appropriate) electronic materials (ILFA).

- **Current Awareness Services (CAS) / Selective Dissemination of Information (SDI):** Proactive alerting of users to new publications, journal issues, database updates and subject-specific news to keep users up-to-date (INFLIBNET, LIS Academy).
- **Interlibrary loan and document delivery / Resource sharing:** When an item is not locally available, libraries borrow it from partner libraries or provide scanned documents to patrons, enabling wider access to resources (IFLA, 2009).
- **ICT and e-services (OPACs, institutional repositories, e-resources, databases):** Libraries provide internet access, subscription databases, e-journals, institutional repositories and digital services to support research, teaching and lifelong learning (Research Planning and Review Committee, 2018; INFLIBNET, 2024).
- **Information literacy, user education and orientation:** Libraries teach users how to find, evaluate, cite and use information ethically (workshops, modules, one-to-one instruction) (Bates, 2010; INFLIBNET).
- **Study spaces and learning commons:** Libraries provide quiet reading rooms, group study spaces and collaborative learning facilities that support formal and informal learning (Jharotia & Mishra, 2024).
- **Preservation and special collections / Archives management:** Libraries preserve rare, heritage and institutional records using conservation, digitisation and archival practices to ensure long-term access (Hotsonyame, 2023).
- **Community outreach, literacy and cultural programming:** Public libraries in particular run reading programs, children's activities, community events and outreach to underserved groups (IFLA, 1994).
- **Support for research and scholarly communication:** Academic libraries support researchers through research data services, repository management, bibliometrics, faculty support and open access advocacy (Research Planning and Review Committee, 2018; Jharotia, 2024).
- **Policy, advocacy and social inclusion:** Libraries act as civic spaces that promote inclusion, lifelong learning, digital literacy and access to public information, per UNESCO/IFLA principles (IFLA, 1994).

- **Reference collections and bibliographic services:** Maintenance of curated reference collections, indexes, bibliographies and guides that orient users to authoritative sources (INFLIBNET).
- **Technical and preservation services (digitisation, metadata, digital preservation):** Libraries undertake digitisation, digital curation, metadata creation and preservation of born-digital and scanned content (Hotsonyame, 2023).

3.4 Challenges Faced without Automation

- **Manual cataloguing and classification errors/inefficiency:** Without automation, cataloguing, classification, and indexing are done manually, often leading to inconsistent entries, misplacement of items and difficulty in retrieval. This slows down service to users (Jaiswal & Pandey, 2024; Chandrashekara *et al.*, 2012).
- **Labour-intensive circulation and stock maintenance:** The manual process of issuing, returning, tracking books, and physical inventory is time-consuming, error-prone and requires more staff (Chitra & Kumbar, 2020; Chandrashekara *et al.*, 2012).
- **Limited access to users / low availability of resources:** Non-automated libraries often cannot support remote access, OPAC (Online Public Access Catalogue) or e-resources, reducing the ability of agricultural researchers/farmers to access current information (Chandrashekara *et al.*, 2012; Sharma & Kandari, 2024).
- **Slower information retrieval and reference service:** Without search systems, users must browse manually through cards, shelves or catalogues, increasing waiting time and reducing satisfaction (Chitra & Kumbar, 2020).
- **Poor resource sharing and interlibrary cooperation:** Automation often supports networking, resource sharing (e.g. DELNET, INFLIBNET), but where this is missing, libraries operate in isolation, limiting access to external resources (Chandrashekara *et al.*, 2012; Jayamma & Krishnamurthy, 2017).
- **Insufficient staff training and lack of technical skills:** Manual systems require different skills, but transitioning or maintaining non-automated workflows

often suffer from a lack of trained personnel when modernisation is needed (Chitra & Kumbar 2020; Subaveerapandiyan *et al.* 2021; Jaiswal & Pandey, 2024).

- **Inadequate infrastructure (space, lighting, physical maintenance):** Manual operations need more physical space, well-organised stacks, reading rooms, etc. Without automation, space is inefficiently used or poorly maintained (Chitra & Kumbar, 2020; Sharma & Kandari, 2024).
- **High overhead and operational costs in the long term:** Even though automation has upfront costs, non-automated libraries incur recurring costs in manpower, corrections, loss of books (misplaced or borrowed without record), etc (Jaiswal & Pandey, 2024).
- **Poor handling of e-resources and digital content:** Without automation, integrating e-resources (journals, databases, ebooks) is difficult; manual linking, authentication, usage tracking, etc., are challenging (Subaveerapandiyan *et al.*, 2021; Sharma & Kandari, 2024).
- **User dissatisfaction and limited service scope:** Without automation services like "search from your seat", online catalogues, remote requests, etc., users (e.g. agricultural researchers) are constrained, especially in remote or rural setups (Sharma & Kandari, 2024; Jayamma & Krishnamurthy, 2017; Chitra & Kumbar, 2020).
- **Data management issues and poor record-keeping:** Manual records are more prone to damage, loss, and poor indexing; creating usage statistics or reports is laborious (Chandrashekara *et al.*, 2012; Jaiswal & Pandey, 2024).
- **Difficulty in sustaining services/scalability:** As collections grow, user numbers rise, and handling growth manually becomes unsustainable. Scalability of services is limited without automation (Chitra & Kumbar, 2020; Jaiswal & Pandey, 2024).

3.5 Automation Technologies in Agricultural Libraries

"The use of computers for information storage and retrieval began with the production of computer-generated and printed indices for scientific and technical literature in the 1960s.

Subsequently, several organizations started using computers not only for generation and printing of indices but also for creation of computer readable databases. By early 1970s, several published indexing and abstracting journals, such as Biological Abstracts, Chemical Abstracts, Index Medicus, etc. were not only produced by computer, they were also made available as computer-readable databases on magnetic tapes and several organizations started subscribing to them on magnetic media to organize local information storage and retrieval services” (Jaiswal and Pandey, 2024).

- Library Management Systems (LMS) – Koha, SOUL, NewGenLib, etc.
- Digital Cataloguing and Classification – MARC21, AACR2, RDA
- Digitisation and Digital Repositories – DSpace, EPrints
- Automation in Information Retrieval – OPAC, federated search tools
- Integration of ICT Tools – RFID, barcode systems, QR codes
- AI and Machine Learning Applications – chatbots, automated indexing
- Mobile Applications and Remote Access Tools

3.6 Future Trends in Agricultural Library Automation

- **AI-powered knowledge management systems:** AI and machine-learning tools (including LLMs and retrieval-augmented generation) are increasingly used to index, summarise and recommend domain knowledge, enabling agricultural libraries to deliver personalised research assistance, automatic metadata enrichment and intelligent subject gateways for farmers and researchers. These systems can surface relevant extension material and link research to practice, but require curated training data and governance to avoid bias (Islam *et al.*, 2025; Pichman, 2024)
- **Cloud-based integrated library systems:** Cloud ILS/platforms move library back-end services (cataloguing, circulation, discovery, analytics) off local servers into shared, scalable environments, lowering IT overhead and enabling 24/7 remote access to catalogues and e-resources—vital for agricultural universities and extension libraries serving dispersed rural

users. Cloud adoption also facilitates consortial resource sharing and faster software updates (Jain *et al.*, 2024; Gonzales, 2023).

- **IoT-enabled agricultural information services:** IoT sensors, drones and field devices produce real-time agronomic datasets (soil moisture, pest incidence, microclimate) that libraries can ingest to create dynamic information products (dashboards, alerts, localised advisories). When integrated with library portals and mobile apps, IoT feeds help translate raw sensor data into actionable guidance for farmers, bridging research and field practice (Quy *et al.*, 2022; Digi.com, 2024; Sharma & Shivandu, 2024)
- **Voice-assisted information retrieval:** Voice assistants and conversational agents (Alexa, Google Assistant, custom chatbots) make library content accessible to users with low literacy or limited typing ability, enabling hands-free queries and rapid answers in local languages. Early evaluations show promise for routine reference queries and outreach, but careful design is needed for accuracy, privacy and culturally appropriate phrasing (Dutsinma *et al.*, 2022; McKie *et al.*, 2022; Kumar, 2023)
- **Blockchain for secure information management:** Blockchain and distributed-ledger approaches can provide tamper-evident provenance for institutional records, digitised collections, open-access credentials and licensing transactions helpful for protecting intellectual property, tracking dataset usage and ensuring transparent, auditable records in multi-institution consortia. Practical deployment must address scalability, privacy and interoperability challenges (Ahmad, 2024; Sharma *et al.*, 2025).

4. CONCLUSION

Automation in agricultural libraries is no longer a futuristic aspiration but a present necessity to ensure efficient information access, knowledge dissemination and research support. From the early initiatives like ICARNET and ARIS to modern systems such as CeRA, IDEAL and Krishikosh, Indian agricultural libraries have made significant strides in leveraging ICT for knowledge management. Yet, challenges such as manual inefficiencies, limited resource sharing and poor scalability highlight the critical

importance of automation in sustaining agricultural knowledge services.

The review reveals that emerging technologies, including AI-driven knowledge management, cloud-based library systems, IoT-enabled services, voice-assisted retrieval and blockchain-powered security, are redefining how agricultural information is collected, processed and disseminated. These innovations promise not only to reduce drudgery and improve operational efficiency but also to enhance inclusivity by making resources accessible to diverse stakeholders, including researchers, extension workers, farmers and students in rural communities.

However, successful implementation requires strategic investment in infrastructure, capacity building of library professionals and policy frameworks that encourage interoperability, open access and long-term sustainability. Libraries must also align with global knowledge networks while addressing local agricultural challenges to remain relevant in the digital era.

In conclusion, automation offers agricultural libraries the potential to transform into dynamic, smart knowledge hubs that bridge the gap between research and practice, strengthen agricultural education and empower farming communities with timely, reliable and contextual information. Harnessing these technologies responsibly will ensure that agricultural libraries continue to play a central role in advancing food security, rural development and sustainable agriculture in the decades ahead.

5. RECOMMENDATIONS

Based on the findings of this review, the following recommendations are proposed to strengthen automation in agricultural libraries and ensure effective knowledge dissemination:

5.1 For Policymakers

- Formulate national and state-level policies to promote library automation, digitisation and open access in agricultural education and research institutions.
- Allocate dedicated funding for ICT infrastructure, cloud platforms and training of library professionals.
- Encourage collaborative networks (e.g., CeRA, IDEAL, Krishikosh) to expand resource sharing across agricultural universities and research centres.

- Integrate library automation initiatives into broader Digital Agriculture and Smart Farming missions to ensure alignment with rural development policies.

5.2 For Agricultural Library Management

- Adopt modern Integrated Library Management Systems (ILMS) such as Koha or SOUL, ensuring scalability and interoperability with national networks.
- Develop capacity-building programs to train library staff in AI tools, digital repositories and IoT data integration.
- Strengthen digitisation and preservation projects to safeguard rare agricultural literature, research reports and indigenous knowledge.
- Enhance user-centred services such as remote access, mobile apps, voice-assisted retrieval and multilingual interfaces to serve diverse agricultural stakeholders.

5.3 For Researchers and Technology Developers

- Design AI-powered knowledge management tools tailored to agricultural datasets, ensuring bias-free and context-relevant recommendations.
- Explore IoT-data integration with library platforms to provide real-time, localised advisory services for farmers and extension workers.
- Develop blockchain-based solutions for secure, transparent management of agricultural research outputs, intellectual property and licensing.
- Collaborate with agricultural libraries to build open-source and low-cost technologies that rural institutions can adopt without financial strain.
- Conduct impact assessment studies to evaluate how automation influences research productivity, knowledge dissemination and farmer outreach.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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