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DIGITAL LIBRARIES AS A TOOL FOR ENHANCING FARMERS' ACCESS TO RESEARCH INFORMATION SERVICES AT THE NATIONAL ROOT CROP RESEARCH INSTITUTE FOR SUSTAINABLE IRISH POTATO PRODUCTION IN PLATEAU STATE

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Abstract
Digital libraries tools are platforms for enhancing farmers' access to agricultural research and National Root Crops Research Institute (NRCRI) information services in Nigeria. NRCRI plays a vital role in developing and disseminating agricultural innovations via its digital platform and research information services. This study explores how digital library tools can enhance farmers 'access to NRCRI research information services to promote sustainable irish potatoes production in Plateau State. Using a systematic literature review and content analysis, the study objectives are to: identifies NRCRI research information services for sustainable irish potatoes production as follows: agricultural extension and advisory services, training and capacity building services, collaborative research and partnership, on-farm trials and field demonstration, demonstration plots/farmers field school, seed system and inputs provision, digital and online, climate information services. Identify digital libraries tools for enhancing farmers' access to NRCRI research information services: mobile application (agricultural apps), web portals and online resources, institutional repositories, social media for farmers network, interactive voice response, and sensor technologies and Internet of Things. Highlights the benefits of digital library tools as: knowledge sharing, enhancing knowledge dissemination, promoting collaboration, resource

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management and an integrated digital library with emerging technologies. And also, identify the challenges such as: digital divide, capacity building for farmers, users' digital literacy, language and content-related challenges, data privacy, and socioeconomic factors. The study concludes that digital library tools are enablers for enhancing Irish potato farmers' access to NRCRI research information services. Addressing the identified challenges is key to the adoption of digital library tools, which enhance access to information services and contribute to sustainable productivity in Irish potatoes as a food security measure in Plateau State.

Keywords: *Digital libraries, access to information services, NRCRI, Sustainable Irish potato production, digital library tools.*

Introduction

Digital library plays a crucial role in advancing agricultural knowledge and sustainability, serving as comprehensive platforms that provide farmers, researchers, and policymakers with access to an extensive range of information resources such as journals, research articles, databases, and multimedia materials (Choudhary, 2024). A system that stores and provides access to digital content through electronic devices like computers and smartphones. A digital library is the collection of online electronic resources such as e-books, academic e-journals, files, multimedia, digital assets, educational resources, institutional repositories and research articles stored, organised, and made accessible to its users through leveraged information and communication technologies to help them search, retrieve, and interact with a wide range of digital content. Advanced tools and services that make information easy to search, retrieve, and use effectively (Rao & Ranganadham, 2025).

Information services are designed in libraries to assist users in locating published or unpublished information within or outside the library or information centre. Sustainable Irish potato production, therefore, relies heavily on farmers' ability to access and utilise relevant agricultural information services and innovations.

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The Irish potato (*Solanum tuberosum*), also known as the potato, is one of the most important root and tuber crops. A staple food and primary source of income for millions of smallholder farmers, a key to the elimination of poverty and commercialisation of agriculture, and a primary contributor to household food security, nutrition, and rural livelihoods in developing countries (Tumuramye *et al.*, 2025). Plateau State accounts for ninety (90) per cent, and the highest indices of irish potatoes production in Nigeria, and provides a substantial economic contribution to Nigeria due to its favourable agro-ecological conditions (Udoh *et al*.,2025 and Musa, 2025). Irish potatoes offer numerous benefits, including serving as a staple food, a source of income when cultivated commercially (cash crops), and creating job opportunities. Nutritionally, they are rich in antioxidants, vitamins B1, B2, B3, B6 which are very useful in maintaining brain and nervous system health, and vitamins C to repair the wear and tear of the body cells, minerals (potassium, calcium, iron, magnesium, phosphorus, and sodium), and fibre, making them valuable for maintaining health, lowering blood pressure, and reducing cholesterol levels (Egesi, 2023 and Akinfewa, 2021). The average potato yield (3.7 t ha^{-1}) in Nigeria remains significantly lower than the crop's potential (Egesi, 2023). To address this, the National Root Crops Research Institute (NRCRI) has been pivotal in developing and disseminating agricultural innovations through its digital and research services. The NRCRI sub-station at Kuru, Jos, established in 1975, has been a key centre for potato research and production expansion. The station addresses challenges such as climatic adaptation, low tuber yields, and inadequate potato supply in Nigeria.

Despite these efforts, Irish potato production in Plateau State has stagnated due to several challenges, including low productivity of existing varieties, inadequate supply of quality seeds, poor post-harvest practices, insufficient farmer education, lack of control of major potato pests and diseases, insecurity/violence, which led to loss of lives, farmland and properties, and limited

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technological advancements (Adama, 2023; Jatbong *et al*., 2018). These challenges raise concerns about the sustainable Irish potato production in Plateau State, Nigeria.

Sustainable agriculture enhances resource efficiency while minimising negative environmental impacts, ensuring food availability for future populations (Sharma *et al*., 2024). Sustainability in Irish potato farming involves adopting environmentally responsible and economically viable practices to maintain agricultural productivity for future generations. These include water conservation, biodiversity protection, and soil preservation (Tijjani & Khairulmazmi, 2020). Sustainable Irish potato farming offers multiple benefits, such as protecting natural resources, reducing fossil fuel dependence, mitigating climate change impacts, and ensuring soil fertility. It contributes to global food security by fostering resilient agricultural systems, promoting biodiversity, and producing healthier, chemical-free crops that reduce public health risks (Kodden, 2020).

Access to information services can change how farmers farm, reduce the use of synthetic chemicals, agrochemicals, and non-renewable energy sources by learning about sustainable practices (Ogbonna and Anunobi, 2022). Farmers obtain information through extension workers, libraries, broadcast media, and ICT platforms (Ogbonna & Anunobi, 2022). This study aims to identify the digital library tools that can enhance farmers' access to NRCRI services for sustainable irish potatoes production in Plateau State, Nigeria.

Objectives for the study

The following are specific objectives for the study:

1. To identify NRCRI research information services for sustainable irish potato production,
2. To identify digital library tools for enhancing farmers' access to NRCRI research information services for sustainable irish potato production,

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3. To highlight the benefits of digital library tools for enhancing farmers' access to NRCRI research information services for sustainable irish potato production, and
4. To identify the challenges of digital library tool adoption by farmers to access NRCRI research information services for sustainable irish potato production in Plateau State.

Review of Related Literature

Farmers have an important role in maintaining ecological balance by implementing appropriate land and water management techniques, protecting biodiversity, and utilising natural resources effectively. Blending traditional knowledge with modern innovations such as precision farming and climate-resilient crop varieties greatly enhances sustainable agricultural practices (World Farmers' Organisation, 2024). To achieve this, farmers need continuous access to knowledge on minimising agrochemical use, improving resource efficiency, and adapting to environmental and economic changes (Ogbonna & Anunobi, 2022).

Access to National Root Crops Research Institute Research Information Services for Sustainable Potatoes Production

Access to NRCRI's information services enables farmers to address agricultural challenges effectively, adopt new technologies, avoid unsuccessful practices, conserve time and resources, and mitigate uncertainty. Through information services, farmers gain knowledge on techniques to improve agricultural productivity, such as using fertilisers, pesticides, and high-quality seeds, as well as accessing credit facilities and market opportunities. This improves their skills and ability to produce more efficiently (Bonephace *et al*., 2022). The following are NRCRI information services:

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Agricultural extension and advisory services: The essential components of sustainable agriculture. NRCRI extension and advisory services connect researchers and farmers, provide training, demonstrations, and useful advice that enhance livelihoods, boost productivity, and support sustainable agricultural practices (Tayang *et al*., 2023; Pallavi *et al*., 2023).

Training and capacity building services (Workshops and training programmes): NRCRI offers training seminars on topics like integrated pest management (IPM), soil fertility, and climate-smart agriculture to empower farmers with information, technical skills, confidence, and creative practices needed for sustainable potato production (Shubham & Kumar, 2024).

Collaborative research and partnership services: Research collaboration and partnership services offered by NRCRI foster interdisciplinary learning, creativity, and practical problem-solving by improving farmer access to information, resources, and cutting-edge technologies through partnerships with non-governmental organisations (NGOs), private organisations, and international bodies (Shubham & Kumar, 2024).

On-farm trials and field demonstration services. These services expose farmers to new technology and best practices through field demonstrations, monitor farms, and research farms. NRCRI helps them learn, assess innovations, and implement sustainable practices to increase potato yield (Sseguya et al., 2021).

Demonstration plots/farmer's field school services. This NRCRI services allow farmers to see better varieties, agronomic techniques, and natural resource management while obtaining hands-on training, testing innovations, and building practical skills for sustainable agriculture (Sseguya et al., 2021).

Seed System and Inputs Provision Services. NRCRI provides high-quality, disease-resistant seeds, advising farmers on how to handle seeds properly, and offering necessary inputs like

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fertilisers and pesticides while encouraging effective and ecologically responsible input usage. NRCRI supports sustainable potato production (Uwaramutse et al., 2023).

Digital and online services. Despite information and communication technologies challenges in rural areas, NRCRI digital services improve decision-making and contribute to modern, productive, and connected farming systems by giving farmers access to weather forecasts, market prices, and pest alerts via radio, television, and online platforms (Mushi et al., 2022; Addison et al., 2024).

Climate information services. In order to help farmers manage climate risks and make well-informed planting and production decisions, climate information services include weather forecasts, seasonal predictions, and advice updates (Carr et al., 2020).

Research and development output (R&D) services: Services for research and development output improve agronomic methods and create climate-resilient, high-yielding potato varieties. NRCRI conducts research and disseminates its results through extension services and training that are tailored to the needs of farmers (Ogola & Ouko, 2021; Egesi, 2023).

Information resources and documentation services. Technical bulletins, research papers, manuals, fact sheets, and policy briefs are among the publications produced by NRCRI that offer stakeholders and farmers useful, evidence-based information for better root crop growth and informed decision-making (Egesi, 2023).

Digital Library Tools for Enhancing Farmers' Access to NRCRI Research Information Services for Sustainable Irish Potatoes Production

As technology becomes more available, ICTs will play an important role in increasing productivity, empowering farmers, and closing the knowledge gap between agricultural institutions and rural people (Priya et al., 2025). Mobile applications and web portals are examples

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of digital library tools that enable farmers to easily access information, expert advice, and online agricultural resources, thereby supporting their information needs and contributing to sustainable agricultural practices. The following are digital library tools:

Mobile Applications for Farmer Engagement (agricultural apps): The agricultural apps are designed to run on smartphones and provide farmers access to a wealth of agricultural information services such as crop cultivation practices, pest and disease management, weather forecast, marketing price and financial advice at their fingertips (Nasr & Ahmed, 2022). These apps, such as agriBORA and ViaziSoko, connect farmers to markets, input suppliers, credit, crop insurance, and extension services, enhancing decision-making, productivity, and access to certified seeds, fertilisers, agrochemicals, mechanisation, and soil testing (Barungi et al., 2025). Other platforms, including Kisan Call Centre, mKisan, Skymet, and IMD Mausam, provide tailored agricultural advice and localised weather forecasts through apps and SMS, supporting smart farming by promoting best practices, reducing crop losses, aiding seasonal planning, and allowing farmers to send images of diseased plants to experts for rapid diagnosis and guidance (Priya et al., 2025).

Web Portals and Online Resources: They contain full-text current and retrospective materials of electronic information resources such as journal articles, e-books, and digitised materials. The agricultural online databases are Access to Global Online Research in Agriculture (AGORA), The Essential Electronic Agriculture Library (TEEAL), Health Internetwork Access to Research Initiative (HINARI), Agricultural Online Access (AGRICOLA), Agricultural Database (AGRIS), and many others (Mohammed *et al*., 2021). These websites provide access to research papers, extension materials, videos, and e-learning modules on various agricultural topics. A web portal provides facilities for interactive features such as discussion forums and live chat support, allowing farmers to engage with agricultural experts and extension personnel (Rahman *et al*., 2021).

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Institutional Repositories: It is an online locus for collecting, preserving and disseminating in digital form, the intellectual outputs of the staff and students of academic and research institutions. The research output includes electronic copies of peer-reviewed journal articles, theses and dissertations, technical/research reports, conference proceedings, seminar and workshop papers and publications of other intellectual activities in the institution (Igwe, 2014).

Social Media and Farmer Networks: a powerful platform for digital libraries, facilitating knowledge exchange, networking, and information dissemination among farmers and agricultural stakeholders. Timely updates on weather forecasts, market prices and pest outbreaks can be efficiently shared through social media channels. Provide unique opportunities for farmer engagement, peer learning, collaboration, and knowledge exchange on platforms such as Facebook, Twitter, WhatsApp and Instagram. A virtual space where farmers can connect with experts, extension agents, and fellow farmers to share experiences and seek advice (Ngwenya et al. 2020).

Interactive Voice Response (IVR) systems: IVR enables farmers to obtain agricultural information and advisory services via phone calls, giving a user-friendly and interactive interface. Dialling a specific number allows farmers to listen to pre-recorded messages on crop management, pest control, weather updates, and market prices (Acharya et al., 2022).

They also enable interactive communication, multi-lingual support, and enhance inclusivity and usability (Ssekabira et al., 2020).

Sensor technologies and the Internet of Things (IoT) are transformative tools in agricultural digital library systems, allowing for data-driven decision-making, precision farming, and sustainable resource management. Sensor technologies capture and send data on soil moisture, temperature, humidity, pH, nutrient content, and crop health, giving farmers detailed information

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for better crop management (Younis et al., 2021). IoT connects physical devices such as sensors and actuators to the Internet, enabling seamless data interchange and real-time monitoring across farming systems (Kamble et al., 2022). Sensors and IoT work together to assist precision farming by allowing for site-specific input application, decreasing resource waste, minimising environmental effect, and increasing yields (Singh et al., 2020). The data generated are analysed through decision support systems (DSS) that employ analytics, machine learning, and artificial intelligence to provide actionable recommendations, enhancing farmers' ability to make evidence-based decisions and improve efficiency and productivity (Pallavi *et al*., 2023)

Benefits of Digital Library Tools for Enhancing Farmers' Access to NRCRI Research Information Services for Sustainable Irish Potato Production

Knowledge Sharing, Collaboration, Networking and Open Access. Digital libraries tools foster collaboration among researchers, farmers, and policymakers by promoting interdisciplinary research through shared platforms and repositories; supporting collaborative projects through shared access to datasets and publications and encouraging open access to research outputs to enhance knowledge dissemination. Digital libraries provide interactive areas for researchers, scientists, farmers, academics, and extension workers to share agricultural knowledge and problem-solving (Choudhary, 2024).

Enhancing Knowledge Accessibility and Dissemination. Digital libraries serve as a centralised platform for farmers and academics to access diverse agricultural resources, thereby enhancing knowledge and research depth. They enable the download of various resources such as research papers, technical reports, datasets, multimedia, and teaching materials. Free electronic repositories are especially useful in providing easy access to research outcomes for producers, users, scientists, farmers, policymakers, and other stakeholders in the modern world (Choudhary, 2024).

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Promoting Smart Agriculture by Undertaking Empirical Studies. Digital libraries store agricultural, experimental, sensor, and spatial data to support decision-making for researchers and farmers [26]. They also consolidate best practices, models, simulators, and algorithms used in resource planning, climate resilience, and yield prediction. Integrating data analytics tools within digital libraries such as Internet of Things (IoT), Geographic Information Systems (GIS), remote sensing, and artificial intelligence, providing a structured means of compiling and sharing vast datasets for continued utilisation in agricultural research and practice, enables users to analyse large datasets, extract insights, and make data-driven decisions for precision farming, resource optimisation, and addressing issues such as pest management and climate variability(Balafoutis et al., 2019) and (Andreopoulou *et al*., 2008).

Promoting Collaboration and Knowledge Exchange. Digital libraries foster collaboration between scientists, agronomists, extension officers, and farmers by providing avenues for co-authoring articles, sharing data, and providing guidelines. Such platforms enable one to work with students and researchers from different institutions and disciplines on agriculture-related issues; these exchanges not only bring about innovation but also guarantee that the produced research outputs meet the needs of the end-users to promote the implementation of agricultural research results in the field (Keller *et al*., 2014).

Resource Management and Sustainability. Digital libraries provide timely and up-to-date information for agricultural decision-making, ensuring that users have access to timely and relevant information essential for decision-making and staying abreast of industry developments. The availability of updated information on Integrated Water Management, Soil Conservation, and Integrated Pest Management and Disease Management enables farmers to adopt sustainable agricultural practices that reduce adverse environmental impacts. Ironically, libraries also give

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examples and success stories, showing farmers and policymakers better ways of doing things (Choudhary, 2024).

Integration of Digital Libraries with Emerging Technologies. Advanced technologies such as Geographic Information Systems (GIS), the Internet of Things (IoT), and artificial intelligence (AI) have reformed agricultural operations by enhancing the precision, efficiency, and effectiveness of digital libraries. When integrated into the infrastructure of digital libraries, these technologies provide data in real-time, combined with advanced analytics and even predictions, making decisions superior while streamlining agricultural processes (Choudhary, 2024).

Challenges of Digital Library Tools Adoption by Farmers to Access Information Services

Digital divide, Access to Technology and connectivity. One of the primary challenges is the digital divide, which refers to the disparities in access to technology and internet connectivity between rural and urban areas. Limited access to smartphones, computers, and high-speed internet in rural and remote regions can impede farmers' ability to utilise digital extension services. This inequality in technology access can exacerbate existing disparities and leave certain segments of the farming population underserved (Rao & Ranganadham, 2025). Digital library devices with high-technology sensors, such as IOT, can be hampered by power availability and connectivity challenges, especially in rural areas, as many rural farming communities experience poor network connectivity, unreliable electricity supply, and weak ICT infrastructure, hindering the regular use of digital tools such as mobile applications and e-extension platforms (Choudhary, 2024). Affordability further compounds this problem, since many smallholder farmers cannot afford smartphones or continuous data subscriptions, thus widening the gap between digitally connected and disconnected populations.

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Capacity Building and Training for farmers. For successful implementation, irish potato farmers must be adequately trained to use digital library tools effectively. Many farmers may lack the necessary technical skills and knowledge to operate and troubleshoot digital platforms. Training programs are essential to equip farmers with the required digital literacy to leverage these technologies (Pallavi *et al*., 2023).

User adoption and digital literacy. Low levels of digital literacy prevent farmers, especially women, older adults, and those with limited education from fully utilising ICT-based agricultural services (Fabregas *et al*., 2019). Choudhary (2024) noted that, unfamiliar with digital tools to search for relevant materials and participate in complex digital library systems. **Language and content-related challenges**, and **limit engagement**, as most digital platforms use national languages and often neglect local dialects and agricultural contexts. In addition, gender and social inequalities restrict women and marginalized groups from accessing or controlling digital devices, while information overload and misinformation from unverified online sources reduce farmers' trust in digital advisories (Zhang *et al*., 2021).

Data Privacy and Security Concerns. Digital agricultural information services involve the collection and storage of sensitive data, including farmers' personal information and agricultural practices. Ensuring data privacy and security is critical to building trust among farmers and protecting their data from unauthorised access or misuse. Implementation efforts must prioritise robust data protection measures and compliance with relevant data privacy regulations. farmers' personal and farm-related data are frequently collected and stored without proper consent or protection, creating risks of surveillance and misuse (Zhang *et al*., 2021). Vulnerability to cyber-crimes in IoT-connected systems and databases requires safeguards in place in the form of security

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measures (Choudhary, 2024). Addressing these challenges is crucial for promoting inclusive, equitable, and sustainable ICT adoption in agriculture.

Cultural and Socioeconomic Factors. Cultural norms and socio-economic factors can influence the acceptance and adoption of digital technologies in agriculture. Traditional farming practices, beliefs, and resistance to change may hinder the uptake of digital library tools. Additionally, limited financial resources and the cost of accessing technology may be prohibitive for some farmers (Pallavi *et al*., 2023).

Conclusion

The study concludes that digital library tools are enablers for enhancing Irish potato farmers' access to NRCRI research information services. Access to NRCRI research information services for sustainable Irish potato production in the Plateau can be facilitated through digital library tools if the following factors are taken into consideration: the digital divide, capacity building and training for farmers, socio-economic factors, user adoption and digital literacy, data privacy, and language barriers. Addressing the challenges is key to the adoption of digital library tools, which enhance access to information services and contribute to sustainable productivity in Irish potatoes as a food security measure

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