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TOOLS & METHODS

Harnessing artificial intelligence and machine learning for transformative African knowledge hubs: a road map for last-mile knowledge delivery and agricultural modelling

Oluwaseun Bolarinwa Akinyemi, Emmanuel Amek Akoto, Bosede Adeyinka Ayinla, Narcisse Yehouenou, Kgothatso Lovey Tshipo, Guy Marius Assogba, Israel Non-Nde Djidaainairi & Ishmael Kgosietsile Maikano

Abstract

This article explores the transformative potential of artificial intelligence (AI) and machine learning (ML) for developing and enhancing agricultural knowledge hubs across Africa. As agriculture remains central to food security and sustainable livelihoods on the continent, there is an urgent need to close the knowledge gap between scientific advancements and smallholder farmers. This study presents a guideline for integrating AI/ML technologies into agricultural knowledge hubs, highlighting their capacity to improve data aggregation, user engagement, interoperability, and the delivery of timely, context-sensitive knowledge to the last mile. In addition to detailing the technical infrastructure and policy recommendations necessary for success, the article also addresses challenges related to digital divides, data governance, and trust. Emphasizing inclusivity, collaboration, and ethical use, this road map seeks to guide national and regional stakeholders toward building resilient, intelligent knowledge systems that empower agricultural communities, foster innovation, and promote long-term development outcomes across Africa. The article was written as part of the Knowledge Management for Agricultural Development (KM4AgD) Challenge 2024, an initiative of the Forum for Agricultural Research in Africa (FARA) and collaborating institutions.[i]

Keywords: artificial intelligence; machine learning; knowledge hubs; knowledge platforms; agricultural innovation; digital transformation; Africa

1 Introduction

The agricultural sector holds immense potential to transform the African continent. While it accounts for over half of the world's arable land, approximately 600 million hectares, the continent's use of its vast resources for agricultural growth and development pales in comparison to other continents. Despite these resources, Africa remains a net importer of food, spending over USD35 billion annually on food imports rather than harnessing its own agricultural potential (IFAD, 2024). The interconnected challenges of sustainable agriculture, food security, and poverty reduction lie at the heart of global development efforts, as underscored by the United Nations' Sustainable Development Goal 2 (SDG 2) – 'Zero Hunger' (United Nations, 2015). Knowledge is a foundational driver for achieving multiple SDGs, particularly SDG 2 and SDG 1, as highlighted by Yerramareddy and Babu (2018). Their work underscores that open-access data and knowledge dissemination are essential for empowering stakeholders, from policymakers to smallholder farmers, with evidence-based solutions. In Africa, agricultural knowledge hubs serve as critical platforms to bridge the gap between research, policy, and on-the-ground implementation, ensuring that smallholder farmers—who

produce up to 80% of the continent's food, can access and adopt innovative, climate-smart practices (FAO, 2020; World Bank, 2020). This, in turn, strengthens food and nutrition security while lifting rural communities out of poverty, demonstrating how localized knowledge systems are indispensable for achieving SDG 2 and its linked goals of equity and environmental sustainability (Pretty et al., 2018).

While Africa's agricultural productivity continues to face systemic constraints, including insufficient political commitment, weak policy frameworks, and serious underinvestment (IFAD, 2024), knowledge hubs, like FAO's Data in Emergencies (DIEM) hub, exemplify how data-driven platforms can mitigate these barriers. By converting real-time monitoring of shocks (e.g., droughts, conflicts) into targeted interventions, DIEM enhances decision-making for agricultural resilience (FAO, 2025), demonstrating the transformative potential of knowledge systems even in resource-constrained contexts. FAO (2025), suggest that the DIEM hub's success in directing emergency responses, such as its rapid assessment following Afghanistan's 2023 earthquakes, exemplifies its capacity to bridge the knowledge-to-action gap in crisis situations. This model offers valuable lessons for African agricultural knowledge hubs in leveraging data to strengthen food security and livelihood protection.

With an estimated 33 million smallholder farms contributing up to 70 percent of the region's food supply (AGRA, 2017), empowering these farmers with access to modern agricultural knowledge and techniques can have a profound impact on food production and poverty reduction. Information and communication technologies (ICTs) are proving instrumental in addressing Africa's food security challenges by enabling real-time data sharing, improving agricultural decision-making, and connecting stakeholders across value chains. Recent evidence demonstrates that digital agriculture solutions can significantly reduce post-harvest losses while enhancing productivity and market access (Tsan et al., 2019). Several regional and subregional actors recognize the need to bridge the knowledge gap and have initiated various initiatives that integrate local knowledge with technological advancements to improve agricultural productivity.

Organizations such as the Forum for Agricultural Research in Africa (FARA), the International Livestock Research Institute (ILRI), and the African Forum for Agricultural Advisory Services (AFAAS) have recognized the need to bridge these existing gaps by prioritizing investments in the establishment of knowledge hubs, as highlighted by Lihasi (2024), Kakuwa-Kasongamullio (2024), and Victor (2024). These hubs enhance access to critical resources while fostering a conducive policy environment supporting sustainable agricultural development.

Despite the concerted efforts of apex agricultural research and advisory bodies in Africa, many knowledge hubs have not yet scaled or achieved their intended objectives. This is due to various challenges, including funding constraints, infrastructural limitations, lack of localized knowledge, poor collaboration, and digital literacy issues. However, the advent of digitalization and artificial intelligence (AI) presents an opportunity to revolutionize how knowledge is accessed and used across various sectors worldwide (Trendov et al., 2019; FAO, 2022). By leveraging such emerging technological advancements, we can ensure the democratization of knowledge (Stiglitz, 1999; David & Foray, 2003) and effectively reach the last mile with relevant and timely information (Goyal, 2010), thereby transforming the dissemination and application of agricultural knowledge in Africa. Furthermore, preliminary findings have established the near-absence of national agricultural knowledge hubs across the continent, creating a gap or inefficiency in the knowledge flow from the local to the continental level. While Africa is awash with knowledge assets, the need is strong to establish and strengthen the base hubs (OECD, 2013).

To further strengthen the argument for a robust foundation, valuable knowledge assets are dispersed across various platforms that can serve as critical resources for training agricultural AI models. In light of this, this article posits that the flow of knowledge to and from the last mile to national and regional stakeholders can be significantly enhanced with the adoption of the appropriate framework and recommendations.

In this article, we aim to develop guidelines for establishing agricultural knowledge hubs. The specific objectives are to:

a. Elucidate the concept of agricultural knowledge hubs, their roles and significance in advancing agricultural development.
b. Examine the current landscape of agricultural knowledge hubs across the continent, their challenges and limitations.
c. Explore the integration of digitalization and AI and machine learning into agricultural knowledge hubs to enhance their effectiveness in delivering knowledge to the last mile.

d. Develop a framework for establishing national agricultural knowledge hubs that are interconnected, sustainable, and capable of enhancing the flow of agricultural knowledge to the last mile and back across Africa.

2 The current landscape of knowledge hubs

Knowledge hubs are integrated platforms designed to facilitate the creation, storage, sharing, and use of knowledge within an organization or community. These hubs are digital spaces where knowledge assets, such as best practices, expertise, lessons learned and intellectual capital, are collected or linked, curated and categorized, and made accessible to members (Gabriele et al., , 2017). While acknowledging that knowledge hubs can exist in both digital and non-digital formats, including as communities of practice, Evers, Gerke, and Menkhoff (2010, 2011) argue that the primary objective of knowledge hubs is to harness collective knowledge and experiences across individuals, teams, and organizations while facilitating knowledge sharing and collaborative practices. To reinforce this postion, van Paassen and colleagues (2013) suggest that such innovation platforms are positioned to reduce redundant efforts, mitigate knowledge loss associated, and promote continuous learning and innovation, particularly when driven by a clear vision of the overall purpose.

Building upon the recognition of their different manifestations, knowledge hubs may be operationalized through various forms, encompassing physical infrastructures such as libraries or resource centers, digital environments including intranets, wikis, or knowledge management systems, or integrated approaches that combine both physical and virtual elements. Given the inherent characteristics of knowledge hubs as knowledge repositories and sharing platforms (Evers, 2008), such systems typically incorporate functionalities including search engines, taxonomies, discussion forums, and collaboration tools to facilitate seamless access, organization, and exchange of knowledge assets. In essence, these systems can play a crucial role in supporting activities such as onboarding and training new employees, problem-solving, decision-making, and fostering a culture of continuous learning and improvement (Somasundaram, 2023). They can also serve as a means of capturing and preserving institutional knowledge, ensuring that valuable knowledge and experiences are not lost when employees leave the organization (Brar et. al, 2023).

Recognizing knowledge as a critical organizational asset (Bollinger & Smith, 2001), knowledge hubs are especially beneficial in knowledge driven sectors, including agricultural research, development consulting, healthcare, and education. Collective knowledge, when systematically organized, has been shown to strengthen innovation and operational outcomes (Andreev, 2022). In response to the crucial need to advance knowledge management for agricultural development, various agricultural actors have taken giant strides towards establishing Agricultural knowledge hubs at continental and subregional levels. These hubs have been designed to serve multiple purposes, including facilitating knowledge sharing, promoting innovation, supporting evidence-based policymaking, and enhancing agricultural productivity and sustainability across Africa. This paper examines existing regional and sub-regional agricultural knowledge hubs across Africa, categorizing them as either fully operational platforms or non-operational systems, with the latter encompassing both existing but inactive hubs and those currently under development or consideration.

2.1 Agricultural knowledge hubs in Africa

In this section, we provide an overview of operational knowledge hubs. The final one is non-operational but has still been included as it is under development.

2.1.1 CGSpace

CGSpace[2] is a repository of CGIAR and partner research outputs and knowledge products, including reports, articles, press releases, presentations, videos, policy briefs, datasets, infographics and more. It currently (6 May 2025) holds 44184 records covering the African continent and 76350 which include reference to Africa. CGSpace emerged from work by the International Livestock Research Institute (ILRI) to make its products public in a state of the art repository. Starting in late 2009, ILRI set up a DSpace repository. Looking for ways to capture products of projects hosted by, but not belonging to ILRI, communities were set up for other initiatives, such as the CGIAR System-wide Livestock Programme. Content is organized in communities and collections and includes outputs from CGIAR's current research and innovation portfolio, outputs of CGIAR research centers and hosted content of other organizations and programmes (CGIAR, 2009).

2.1.2 FARADataInformS by the Forum for Agricultural Research in Africa

FARADataInformS[3] knowledge hub which was established in 2017 is a continental digital platform and repository of African agricultural research outputs and knowledge products, including research papers, policy briefs, technical reports, datasets, institutional profiles, and innovation platform documentation. It currently holds over 2,500 publications, documentation of 400+ innovation platforms, over 40,000 DGroup members, and profiles more than 2,000 AR4D institutions covering the African continent. The hub stemmed from work by the Forum for Agricultural Research in Africa (FARA) to centralize and streamline agricultural data and knowledge for informed decision-making across Africa. This hub functions as a key continental resource and the primary knowledge engine driving Agricultural Research for Development (AR4D). It fosters collaboration among diverse stakeholders across Africa, integrating platforms like AARIEISpace for research output storage and sharing, as well as the FARAAfrica Dgroups community for knowledge exchange. Content is organized in thematic areas and collections and includes outputs from Africa's current agricultural research and innovation portfolio, profiles of AR4D institutions, and hosted content of development partners and programmes aligned with the Comprehensive Africa Agriculture Development Programme (CAADP) and Malabo Declaration commitments (FARA, 2024).

2.1.3 AFAAS knowledge hub

AFAAS knowledge hub[4] is a digital platform dedicated to the aggregation, organisation, and dissemination of agricultural advisory and extension-related knowledge and learning products across Africa. As of 13 May 2025, it houses over 2,000 curated knowledge products, with a specific focus on African agricultural contexts and innovations that support agricultural extension and advisory services. The AFAAS Knowledge Hub was developed by the African Forum for Agricultural Advisory Services (AFAAS) as part of its mission to enhance knowledge sharing and learning among stakeholders in agricultural extension systems across the continent. Initiated under the framework of CAADP XP4 and supported by partners such as FARA and the European Union, the platform is structured around thematic areas and country-level collections, enabling users to browse and access content relevant to specific domains and geographies. It also facilitates content crowdsourcing and encourages the active participation of extension agents, knowledge managers, researchers, and policy actors to enrich and localise the knowledge base (AFAAS, 2020; 2022; 2023).

2.1.4 CCARDESA Knowledge Hub (K-Hub)

CCARDESA Knowledge hub[5] is a regional digital platform for capturing, storing, and sharing agricultural knowledge and innovations across Southern Africa. It hosts over 1,500 records (as of 13 May 2025), including technical reports, research publications, policy briefs, training manuals, multimedia content, case studies, and guidelines. Developed by the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA), the K-Hub supports the organization's mandate to coordinate regional agricultural research and development (R&D). The platform was launched under the CAADP-XP4 programme, with support from partners such as the Southern African Development Community (SADC) and the European Union. The content on the K-Hub is organised thematically and by country, enabling targeted access for stakeholders, including researchers, policymakers, extension agents, and farmers. By providing timely, relevant, and high-quality knowledge, the CCARDESA K-Hub strengthens regional cooperation, promotes evidence-based agricultural development, and supports the transformation of farming systems in Southern Africa (CCARDESA, 2022; 2023).

2.1.5 ASARECA Knowledge Hub

ASARECA knowledge hub[6] is a digital repository and knowledge-sharing platform hosted by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). It is designed to collect, curate, and disseminate agricultural knowledge, research outputs, and innovations across ASARECA's 15 member countries in Eastern and Central Africa. As of May 2025, the Hub contains over 2,000 agricultural knowledge products, and houses the following themes: ASARECA TIMPS Space; Communities of Practice (CoP) and Think Tank; Electronic Library; Agricultural Data and Statistics; Extension Resources; Policies and Strategies; Learning and Innovation; and Emergencies (ASARECA, 2025). The knowledge hub operates within the organization's Strategic Plan framework while supporting continental initiatives including CAADP, KM4AgD, and the Akosombo Integration Agenda for harmonized African knowledge systems. The platform, supported by the CAADP-XP4 Programme in conjunction with the European Union and IFAD funding, thematically structured content according to ASARECA's research areas. In addition to the different

features, the platform also offers bilingual functionality in English and French to serve the sub-region's linguistic requirements (ASARECA 2023).

2.1.6 CORAF/WECARD knowledge hub

According to P. A. Nadinga (personal communication, May 29, 2025) the efforts of the West and Central African Council for Agricultural Research (CORAF/WECARD) in curating sector-specific knowledge, it currently operates specialized platforms like MITA[7] (Market of Agricultural Technologies and Innovations), which showcases scalable agricultural technologies developed or validated in West and Central Africa, and FeSeRWAM[8] (Fellowship and Seed Research for West Africa Movement), which supports the development of regional seed systems through coordination, capacity building, and access to quality seeds. In total, these platforms currently host over 1500 knowledge products. Building on this foundation, CORAF/WECARD is advancing the development of a scalable Digital Knowledge Hub (DKH) aimed at centralizing and democratizing access to agricultural research and innovation across West and Central Africa. The DKH will serve as a strategic platform, integrating a comprehensive repository that aggregates validated research outputs, innovations, technologies, and data from 23 National Agricultural Research Systems (NARS) and CORAF/WECARD-managed platforms.

2.1.7 Conclusions

Although these knowledge hubs are theoretically positioned to contribute to a pan-African agricultural knowledge ecosystem, there is no empirical evidence to suggest interoperability among hubs at regional and continental levels, despite ongoing regional discourse on this topic. This fragmentation limits the effective bidirectional flow of knowledge, both ensuring agricultural innovations reach grassroots practitioners and capturing local insights and indigenous knowledge for broader policy formulation. Consequently, strengthening connectivity between continental, subregional, and national-level stakeholders becomes imperative to facilitate comprehensive knowledge exchange that informs evidence-based agricultural policies and enhances last-mile delivery mechanisms.

2.2 Knowledge flow structure: national to regional

Traditional agricultural knowledge systems often rely on linear, top-down approaches, where agricultural technologies and knowledge products are developed centrally and disseminated to farmers through extension services (World Bank, 2012). However, this model has proven inadequate in addressing the diverse, context-specific challenges of smallholder agriculture (Klerkx et al., 2012). Increasingly, scholars emphasize the need for multi-directional knowledge flows, integrating local, indigenous knowledge with global scientific advancements to foster sustainable innovation (Chambers et al., 1989; Leeuwis & Aarts, 2011). This paper proposes a multi-scalar agricultural knowledge hub framework that facilitates bidirectional learning across local, national, subregional, and continental levels in Africa. By bridging grassroots knowledge with broader research and policy, these hubs enable contextually relevant yet scalable solutions, moving beyond the limitations of one-way knowledge transfer.

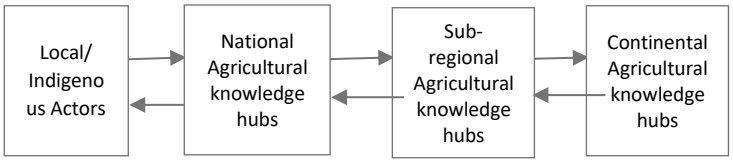


Figure 1. Conceptual flow of knowledge to and from the last mile to the K-Hubs.
Source: Authors

Local participation in this knowledge flow is a crucial part of the entire value chain as it: Acknowledges the value of indigenous knowledge and localized innovations; and ensures that the knowledge shared and solutions developed are relevant and applicable to end-users, primarily farmers. Each component of this structure leverages resources from others to function optimally. Local actors provide ground-level insights and feedback on agricultural knowledge. National agricultural knowledge hubs aggregate this local knowledge, combine it with formal research and provide a country-specific context. Sub-regional hubs facilitate cross-border learning and address shared challenges among neighbouring countries. Continental hubs offer a broader perspective, connect with global knowledge sources, and provide overarching strategies for African agriculture. With this approach, local knowledge and innovations can be scaled up and shared widely, while also enabling the adaptation of broader agricultural advancements to local contexts.

2.3 Situational analysis of existing sub-regional and regional knowledge hubs

To evaluate the current state of agricultural knowledge ecosystems in Africa, a mixed-methods assessment of regional and sub-regional knowledge hubs was adopted. The analysis combined primary and secondary research, including a knowledge café with 50 participants in May 2024 and in-depth interviews with senior personnel from FARA, CCARDESA, AFAAS, CORAF, ASARECA, and CGIAR's CGSpace. The primary research followed a structured SWOT framework, probing strengths (e.g., data infrastructure, network scalability), weaknesses (e.g., technical capacity gaps), opportunities (e.g., AI/ML integration), and threats (e.g., funding volatility). CGSpace was analyzed as a benchmark case through document review, given its recognized visibility within the agricultural knowledge management space.

The knowledge hubs operating across Africa demonstrate several important strengths. These hubs are generally built on robust infrastructure and advanced data management systems, often including large-scale data centers and extensive networks of researchers and experts. Many have embraced Infrastructure as a service models, supplemented in some cases by onsite backup strategies. These hubs benefit from access to a broad array of high-quality data sources, including official documents, peer-reviewed publications, and field research, making them rich and diverse repositories of agricultural knowledge. They have a proven track record of creating and sharing effective agricultural innovations and best practices. Their wide network spans multiple countries and includes researchers, extensionists, practitioners, and policymakers, which ensures accessibility and reach. Additionally, their decentralized knowledge management systems, involving focal persons in member countries and in some cases hybrid models, are increasingly being strengthened by growing capabilities in system integration and data handling.

Despite these strengths, knowledge hubs face several persistent weaknesses. Funding and resource limitations hinder their ability to sustain operations, upgrade systems, and retain specialized expertise. Data integration and platform interoperability remain significant technical challenges, limiting effective collaboration and the seamless flow of information. Many hubs also suffer from a shortage of technical specialists required to manage and enhance their systems. Broader operational and strategic issues, including limited financial flexibility and technical constraints, further curtail their ability to realize their full potential.

However, these challenges are accompanied by meaningful opportunities. There is growing scope for deeper collaboration between knowledge hubs and research institutions, technology providers, and private-sector partners. The integration of artificial intelligence and machine learning offers the potential to significantly enhance the discovery, organization, and sharing of agricultural knowledge. Moreover, opportunities exist to attract funding from international development partners and through public–private partnerships. Expanding the scale and accessibility of knowledge hubs, especially by creating user-friendly platforms and establishing local community centers, would allow them to serve broader and more diverse user groups.

Nevertheless, a range of external threats could compromise these efforts. Political instability in some regions remains a serious risk to operational continuity and long-term viability. The overreliance on project-based grant funding is problematic, as such funding is often tied to specific donor agendas that may not align with the strategic needs of the knowledge hubs. Furthermore, the fast-paced nature of technological change requires continual investment in new tools and in human capital development, which not all hubs are equipped to sustain. Regulatory and compliance challenges, including those related to cross-border data protection laws and international donor requirements, create further complexities. Finally, knowledge hubs continue to struggle with the difficult task of distinguishing valuable knowledge from irrelevant information and ensuring that this knowledge is effectively disseminated and applied.

3 AI and digitalization

The exponential growth of Artificial Intelligence (AI) and Machine Learning (ML) over the last decade has significantly shaped various industries, such as agriculture, finance, and education. As AI and ML have advanced from being just experimental technologies to viable computational tools, they have demonstrated their transformative capabilities within the framework of the Fourth Industrial Revolution (Schwab, 2017; Rashid & Kaursik, 2024; Aijaz et al., 2025). Although the terms AI and ML are often used interchangeably, it is important to note the distinction: AI encompasses a wide range of technologies that mimic human intelligence, whereas ML specifically refers to the creation of algorithms that enable systems to learn from data and make

informed choices (Russell & Norvig, 2021). In agriculture, digitalization involves using sophisticated technologies to effectively generate, store, disseminate, and utilize knowledge products. Beyond the mere adoption of technology, digitalization also requires enhancing digital literacy and addressing the prevailing digital divide among agricultural actors.

3.1 Role and potential benefits of AI/ML and digitalization in agriculture and knowledge hubs

The integration of AI/ML, along with other digital technologies, into agricultural knowledge hubs has markedly enhanced their ability to promote a more efficient, productive, and sustainable agricultural landscape. The aggregation and analysis of data provides substantial benefits. Since AI/ML are inherently data-centric, they depend on extensive and varied datasets to develop models and guide decision-making (Jordan & Mitchell, 2015). Agricultural knowledge hubs can act as key repositories for these datasets, offering stakeholders across the continent essential agricultural information and aiding in the creation of predictive and prescriptive models.

Another very important functionality is interoperability. AI/ML technologies can facilitate the development of secured Application Programming Interfaces (APIs) and semantic frameworks that enable different systems and hubs to communicate and share data effortlessly. AI-enabled tools can generate agricultural ontologies and classification schemes that standardize terminologies across various platforms, enabling consistent data interpretation and integration (Saravanan & Bhagavathiappan, 2024). In cases of system heterogeneity, Ray (2025) discusses how AI-driven middleware approaches, including machine learning-based automation and semantic integration techniques, are instrumental in addressing interoperability challenges in heterogeneous systems. These solutions enhance data accuracy, consistency, and accessibility across diverse platforms. Thus AI-powered middleware solutions can serve as intermediaries to facilitate interoperability and ensure smooth data exchange.

The scalability of services is significantly augmented through the use of AI/ML and other digital technologies. By automating routine data management tasks, optimizing resource allocation, and ensuring data security, knowledge hubs can extend their reach to a wider user base, including remote and smallholder farmers (Mishra & Divyanshi, 2023). This scalability enables hubs to efficiently manage increasing volumes of information and adapt to the changing needs of agriculture. Moreover, AI/ML can substantially improve user engagement. Through personalized user interfaces and AI-enabled chatbots, knowledge hubs can deliver real-time support, tailored recommendations, and interactive learning experiences. For instance, the FarmerChat initiative demonstrates how generative AI-powered chatbots can provide personalized, contextually relevant agricultural advice to smallholder farmers, thereby enhancing the scalability and effectiveness of agricultural services (Singh et al., 2024). These features enhance the user experience by catering to individual preferences and facilitating dynamic interactions.

Knowledge sharing is another area where AI/ML capabilities can bring about noteworthy change. AI-driven systems can break down language barriers through Natural Language Processing (NLP), provide intelligent content curation, and create personalized learning pathways. Such functionalities not only enhance user experience but also promote a culture of collaboration and informed decision-making (Sylvester, 2017; Hussein et al., 2016; Wu et al., 2016).

Finally, AI/ML technologies contribute to resource optimization by offering insights through precision agriculture, predictive analytics, and real-time monitoring. These tools support sustainable agricultural practices by enabling efficient use of inputs, reducing waste, and increasing yields (Kamilaris, Kartakoullis, & Prenafeta-Boldú, 2017; Liakos et al., 2018; Wolfert et al., 2017). Collectively, these capabilities highlight the transformative potential of AI/ML-powered knowledge hubs in modern agriculture.

3.2 Challenges and considerations

Despite their advantages, the integration of AI/ML technologies into agricultural knowledge hubs is faced with diverse challenges. A key issue is the quality and availability of data, particularly in developing countries. Chapman (2025) and Dymling (2024) in their articles on suggest that fragmented and inadequate datasets weaken the reliability of AI outputs, complicating the processes of model training and deployment. To enhance data quality, strategies must focus on engaging communities for the collection of indigenous knowledge, utilizing IoT and mobile technologies for real-time data gathering, and adopting standardized tagging and taxonomies (United Nations Economic Commission for Africa [UNECA], 2021).

Technological infrastructure deficits pose another significant barrier. The computational and bandwidth

requirements of AI/ML tools often exceed the capabilities of local institutions and users. Although cloud-based AI services offer a viable alternative, their high cost can restrict accessibility. Innovations in efficient AI hardware, such as neuromorphic chips, offer promising pathways to mitigate computational overheads and reduce financial constraints (University College London , 2022; Indiveri & Liu, 2015).

Attention must also be given to hardware and software considerations. High initial costs, software licensing, infrastructure maintenance, and cybersecurity all constitute essential but resource-intensive components of AI/ML integration. These investments may be prohibitive, particularly for underfunded institutions.

Connectivity remains a persistent issue, particularly in Sub-Saharan Africa. Internet penetration in Western, Eastern, and Central Africa is significantly lower than in the Southern and Northern regions, with about 60% of the population lacking access to reliable internet (Statista, 2024). This gap restricts access to digital knowledge platforms and hampers real-time data exchange. Factors contributing to this situation include the reluctance of telecom companies to invest in rural areas and the high cost of data for low-income farmers. Nevertheless, initiatives such as Rwanda's "Last Mile Project"—which employs drones and TV white space (TVWS) to deliver broadband—exemplify promising innovations. The International Telecommunication Union (ITU) has advocated for the use of TVWS technologies, emphasizing their potential to lower costs and enhance last-mile access (ITU, 2020).

Adoption and usability are equally critical. AI/ML tools must be designed with diverse users in mind, from experienced agricultural professionals to novice smallholders. Training and onboarding programs are vital for effective tool use, while ongoing feedback mechanisms can ensure that platforms evolve to meet user needs. Without strong user uptake, the benefits of these technologies will remain unrealized.

Finally, trust, privacy, and security must be foundational principles. Stakeholders must have confidence in the platforms to protect their data and act ethically. Bias mitigation in model development, robust cybersecurity protocols, and transparent governance mechanisms are essential to fostering trust and enabling responsible knowledge sharing.

3.3 Ethical and regulatory considerations

Ethical and regulatory frameworks are pivotal in steering the deployment of AI/ML in agricultural knowledge hubs. Following OECD AI principles (OECD, 2019), it is important to review and align national legislative instruments on data privacy and protection with cross-border initiatives to ensure interoperability and trust.

Similarly, to guarantee data privacy and security, stringent data protection measures must be implemented, informed user consent must be obtained, and transparency concerning data usage must be established. Ethical AI also requires a focus on fairness and bias. Identifying and mitigating sources of algorithmic bias—whether they stem from datasets, coding practices, or user interactions—is essential. Regular model audits are necessary to ensure equitable outcomes for all users (Coded Bias Documentary).
Transparency and accountability are equally vital. Platforms should clearly articulate their operational mechanisms, decision-making processes, and lines of responsibility. This transparency enhances user confidence and institutional integrity.

Accessibility and inclusivity should also be central to system design. Digital knowledge hubs must be accessible to users with disabilities and to marginalized persons to ensure equitable access to agricultural knowledge. Design practices should consciously avoid reinforcing existing social disparities.

Finally, data should be handled ethically and responsibly. Clear guidelines must govern data collection, usage, and protection to prevent the misuse of sensitive information. Responsible data governance underprops the sustainability and societal acceptance of AI/ML technologies in agriculture. It is noteworthy to mention that the ethical and regulatory considerations outlined above are consistent with the recommendations of the OECD's Council on Artificial Intelligence (OECD, 2019), which emphasize transparency, accountability, and robust data governance.

4 Recommendations and requirements for establishing national knowledge hubs

4.1 Clear vision and objectives

The policy document for the establishment of a national agricultural knowledge hub should incorporate insights from existing knowledge frameworks, including the Accra Declaration: Knowledge Management for Agricultural Development (KM4AgD) Agenda, the Akosombo Integration

Agenda (FARA, 2020; 2021), and Checklist for the development of portals for international development (Cummings et al., 2019). This paper suggests that national knowledge hubs should feature the sections outlined in Table 1.

Table 1: Key components of national agricultural knowledge hub policy framework

Recommendation	Section	Description
Clear vision and objectives	Purpose	Define the primary knowledge goals, e.g. "The National Agric K-Hub serves as a centralized platform for collecting, disseminating, and exchanging agricultural information, resources, and best practices. It aim to enhance sector productivity, sustainability, and resilience by facilitating collaboration and knowledge sharing among stakeholders, supporting decision-making, and promoting innovation and technology adoption."
	Vision and mission statements	A concise statements that outline the long-term goals of the K-Hubs and a brief description of how the K-hub intends to achieve its vision.
	Scope	This section covers the boundaries and focus areas of the national Agricultural knowledge hub. It can include geographical coverage, target audience, knowledge domain, services offered, agricultural sectors, and much more.
	Core objectives	Overarching aims that define what the establishment of the Agricultural knowledge hub wants to achieve in the long term.
	Strategic goals	Specific, measurable outcomes that contribute to achieving the core objectives
	Guiding principles	Establish fundamental values or beliefs that shape and drive the culture within the Agricultural knowledge hub
	Alignment with national goals	Clearly state how the objectives of the hub align with and contribute to national policies and goals.

4.2. Stakeholder engagement/knowledge partnership

Engage stakeholders to gather valuable insights, perspectives and requirements that are crucial for the successful development and implementation of the knowledge hub. This collaborative approach helps identify the specific needs and priorities of the target audience, and offers a sense of ownership and support to all relevant parties. As emphasized by Cummings and colleagues (2019), understanding users is essential. Authorities responsible for establishing knowledge hubs should actively engage the stakeholders listed in Table 2. Establish a legal entity to host and facilitate the knowledge partnership to assure the collaborative character of the knowledge partnership and independence from the stronger players.

4.3 Infrastructure

4.3.1 Digital infrastructure

Prerequisites for setting up and operationalizing an agricultural knowledge hub include: high-performance servers and storage systems; constant electrical power; high-speed internet to support large-scale data storage, processing and access; and a robust data and cyber security. It is essential for the digital solution to separate applications from storage, enabling resource optimization, easier maintenance, and improved fault tolerance. The cost implications for the overall digital infrastructure could be a major drawback to implementing the agricultural knowledge hub. This guideline recommends a scalable IT infrastructure that ensures the hub's technology grows in tandem with its content and user base. As the volume of knowledge products

grows and traffic increases, the infrastructure can be expanded to accommodate the demand. This scalability approach ensures seamless storage, processing power, and bandwidth expansion. Various infrastructure options exist, notable ones are: infrastructure as a service; self-owned infrastructure; co-location services; and hybrid infrastructure. Each option has its own benefits and trade-offs in terms of cost and control, and an overall assessment will be necessary to decide the best fit.

Table 2. Key stakeholders in the national agricultural knowledge hub

Recommendation	Stakeholders	Roles
Stakeholder engagement/ knowledge partnership	Government/ ministries:	Engage relevant government bodies (policymakers) for support to ensure alignment with national policies and standards, access to public resources and harmonization with existing systems and tools
	Academic institutions	Involve universities and research centers for access to scholarly expertise and research outputs
	Farmers/processors/ marketers/traders/ industry participation	Engage businesses and industry representatives to ensure the hub addresses real-world challenges and promotes innovation
	Public and community	Encourage contributions from the general public for inclusion and to ensure the hub meets societal needs
	Others	International agricultural organizations, organized private sector, cooperatives, NGOs, financial institutions
	Facilitator	Identify a neutral facilitator who can engage equally with all stakeholders and maintain a culture of collaboration and trust, while applying professionally a portfolio of methods and tools to identify, acquire, create, share, apply, and capture knowledge, and to manage it in a targeted, systematic, and integrated manner.

4.3.2 Physical infrastructure

This guideline recommends a partnership with state institutions, academia, industry players, and other private sector actors to establish and operate a national agricultural knowledge hub. To this end, the state could be impressed upon to provide the physical infrastructure for hosting the agricultural knowledge hub. Whereas the 'infrastructure as a service' option does not require physical infrastructure, an agricultural knowledge hub agricultural knowledge hub requires a secure location. From a modest front office that presents a go-to for users to a complex data center, an agricultural knowledge hub must be located in a secured physical location that is not flood-prone and relatively safe from natural disasters like earthquakes and fire. Security for an agricultural knowledge hub is not a one-time action but encompasses processes and behaviors that must be embedded into the culture of the agricultural knowledge hub system. From cybersecurity to the physical perimeter, the adage 'security gives way to conspiracy' should be the guide. Overzealous security measures can lead to various conspiracy theories that could negatively impact the usability of the Agricultural knowledge hubs. They could also trigger the activity of hackers and cyber fraudsters. This principle extends to digital and physical infrastructure, data privacy, model integrity, and algorithm transparency. The catch here is to implement strong cybersecurity protocols to protect sensitive data and intellectual property.

As indicated earlier, building trust relationships among stakeholders is also an essential security measure. Implementing explainable AI (XAI) approaches, which gives the stakeholders insight into how the AI makes decisions, is a key trust component. Instilling a sense of ownership of the system is also key to building trust, which culminates in the security of the system.

4.4 Data/information/knowledge management

Highlighted in Table 3 below are some key considerations when managing data/information/ knowledge efficiently in an agricultural knowledge hub.

Table 3. Key aspects of date/information/knowledge management

Recommendation	Considerations	Descriptions
Data/information/ knowledge management	Data/information/ knowledge collection	Establish mechanisms for continuous and systematic data collection from various sources.
	Data/Information integrity	Establish data validation processes; regularly audit and clean data
	Knowledge organization	Implement a clear structure and taxonomy. Use metadata and tagging for easy retrieval
	Data/information/ knowledge integration	Develop platforms for integrating data/information/knowledge from disparate sources to create comprehensive datasets. Ensure compatibility with existing systems. Provide APIs for data exchange
	Data scalability	Adopt an infrastructure that supports growing data volumes. Implement efficient storage and retrieval methods
	Data analytics	Leverage advanced analytics tools and techniques to analyze data to extract valuable insights to improve the knowledge hub
	Data backup and recovery	Establish a regular backup data schedule and maintain a disaster recovery plan to protect critical data
	Compliance	Ensure alignment with data governance policies and regulatory standards to maintain security and ethical data practices.

4.5 Technology and tools

Developing a comprehensive agricultural knowledge hub necessitates the integration of cutting-edge technologies and tools. The key technological components that should be considered when building an effective Agricultural knowledge hub include a knowledge management system.

4.5.1 Knowledge management system

A knowledge management system plays an important role in an agricultural knowledge hub, guiding how the hub systematically categorizes and structures diverse agricultural information, creates and manages taxonomies and metadata schemas for easy retrieval, facilitates content creation and curation from various sources, and enables collaboration support and version control as well as information dissemination to end users. A knowledge management system necessitates the need to deploy an IT architecture to efficiently search, acquire, share, apply, capture, and organise agricultural knowledge. This system should enabled to link various knowledge sources seamlessly and facilitate easy access for all stakeholders. Collaboration platforms/tools also play an essential role in knowledge management systems. They serve as integrated solutions that facilitate effective communication, knowledge exchange and collaboration among diverse agricultural stakeholders. To mention but a few, these platforms include virtual meeting spaces, discussion forums, and project management tools. With recent advancements in AI/ML, leveraging such advanced algorithms can greatly impact automating complex data analysis, predicting agricultural trends, and providing personalized recommendations to farmers and policymakers.

In addition to other features, application of data analytics and visualization tools to process large datasets and create intuitive visuals, will enable a better understanding and improve decision-making processes in agriculture. Furthermore, to ensure inclusivity and a wider adoption of agricultural knowledge products, it is crucial to develop mobile applications and tools to extend the reach of agricultural information and services to remote areas.

Finally, given the high cost of proprietary technologies, which further complicates the efforts of reaching the last mile, Cummings et al. (2019) suggest that leveraging open-source platforms/technology can be a cost-effective solution to encourage innovation and foster a collaborative ecosystem in agricultural technology development.

4.6 Human capital

Human capital represents the core of the knowledge cycle and knowledge assets of the KM4AgD framework (Abugri & Brandner, 2021). It is the people who deliver knowledge processes, products, and services to ensure sustainable agricultural development. Each country should consider aspects of human capital when establishing a Agricultural knowledge hub (Table 4).

Table 4. Key components of human capital for national agricultural knowledge hubs

Recommendation	Component	Description
Human capital	Core team composition	A team of experts in KM, information technology, project management, and domain-specific fields
	Skills and competencies	The national Agricultural knowledge hub team requires a diverse skills set. This includes expertise in various agricultural disciplines, and strong data management and analysis capabilities. Team members should be digital literate and proficient in the relevant technologies, and have a deep understanding of local agricultural practices and challenges. In addition, project management and communication skills are crucial for effective operation, smooth collaboration and effective knowledge dissemination.
	Training & development	The agricultural knowledge hub should prioritize continuous learning and skills enhancement. This includes regular programs for updating KM systems, data science, analysis and visualisation skills. Furthermore, conducting periodic workshops and seminars on emerging agricultural technologies is also required. The knowledge hubs can also implement an annual national KM4AgD Challenge to foster innovation and competence.
	Collaboration and networking	Creating strategic collaborations and networks is crucial for the establishment and sustainability of any national Agricultural knowledge hub, as they directly influence the quality, quantity and diversity of data and knowledge gathered for the hub's knowledge base. Consider: Communities of Practice; Knowledge exchange platforms, e.g. KM4AgD; Agricultural innovation labs; mentorship programs; exchange programs; thematic networks; and annual knowledge summits.
	Diversity and inclusion	In line with global standards, including ISO 30415:2021: Human Resource Management – Diversity and Inclusion, the hubs must ensure gender-balanced team composition, representation from different regions and agricultural sectors, and inclusion of indigenous knowledge experts.

4.7 Policies and governance

Policies and governance are important in the establishment and effective management and use of a knowledge hub (Table 5).

Table 5. Key policies and governance considerations for a national knowledge hub

Recommendation	Aspect	Description
Policies and governance	Regulatory compliance	Ensure all operations comply with national and international laws and regulations, especially concerning data privacy and intellectual property. Implement policies for handling sensitive or confidential information.
	Governance structure	Establish a clear governance framework with defined roles and responsibilities for managing the hub.
	Data quality policies	Set standards for data accuracy, completeness, and consistency. Implement procedures for data validation and cleaning
	Metadata standards	Develop consistent metadata schemas across the hub. Enforce metadata tagging for improved searchability
	Ethical standards	Develop and enforce ethical guidelines for data usage and knowledge sharing and collaboration
	Performance metrics and indicators	Define metrics to measure the effectiveness of the knowledge hub. Implement regular reporting and review processes.

4.8 Funding and sustainability

The establishment and long-term operation of a national agricultural knowledge hub require an effective funding strategy (Table 6). This component ensures the hub's stability, growth, and ability to deliver value consistently.

Table 6. Key funding and sustainability strategies for a national agricultural knowledge hub

Recommendation	Strategy	Description
Funding and sustainability	Initial funding	Secure seed capital from government allocations, grants from international development organizations, private investments, or international organizations.
	Public–private partnerships	Establish partnerships with public and private sector bodies and adopt a co-funding approach for specific initiatives or long-term programs.
	Sustainable business model	Develop revenue models such as subscription-based services, strategic partnerships, and commercialization of research outputs. Implement tiered access models, data monetization, and service-based revenue streams.
	International funding opportunities	Actively pursue funding from international sources, including agricultural development agencies and global innovation funds.
	Endowment funds	Relevant institutions should collaborate to establish a legislative framework that establishes and supports an endowment fund to provide stable and long-term funding for the operations of the hub.
	Cost management	Implement efficient financial management practices to optimize resource utilization.

4.9 Community building and outreach

Outreach activities help raise awareness about the knowledge hub, attracting a diverse range of stakeholders and expanding its reach and impact. By involving the community in the development process, the knowledge hub can build trust, credibility and sustainability, leading to long-term engagement and success. The following approaches are recommended:

4.9.1 Awareness, engagement and outreach programmes

It is important to organize events, workshops, seminars, and conferences to engage with the wider community and promote knowledge sharing. Outreach campaigns will raise awareness of the hub and its offerings among potential users and contributors. One aspect of this is collecting statements and interviewing key figures. For outreach marketing, use pamphlets, billboards, radios, pop-up adverts on social media, e.g. Facebook and YouTube, to capture the attention of individuals and to share knowledge.

4.9.2 Collaboration networks

The agricultural knowledge hub needs to foster networks and partnerships with other knowledge hubs nationally and internationally to share best practices and resources.

4.10 Monitoring, evaluation and adaptation

Providing knowledge and information as a service to the last mile requires monitoring and continuous improvement. To ensure day-to-day continuous, smooth and useful knowledge delivery at a large scale, the knowledge hub should implement components of Table 7. Figure 2 below further reinforces the importance of implementing an effective monitoring, evaluation and adaptation plan.

5 Framework for applying AI/ML in agricultural knowledge hubs

A successful implementation of AI/ML in agricultural knowledge hubs requires a carefully structured approach that balances technological innovation with human-centered design. This should ensure that these powerful tools truly serve the farming communities they are intended to support.

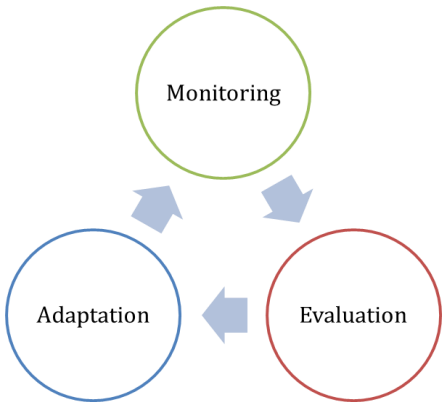


Figure 2. Monitoring–evaluation–adaptation cycle

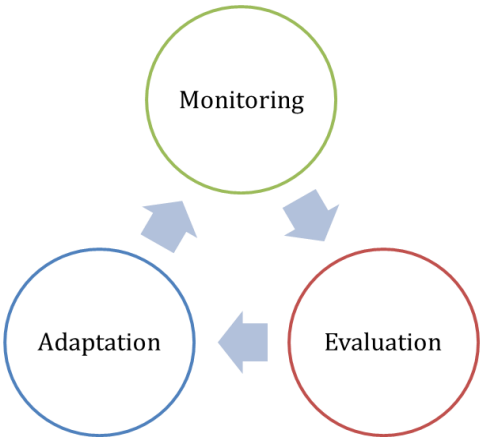
5.1 Guiding principles for implementing AI/ML in agricultural knowledge hub

5.1.1 Core guiding principles

The framework for implementing AI/ML in agricultural knowledge hubs rests upon eight (08) interconnected core guiding principles that work together to create a comprehensive and responsible approach to agricultural technology deployment. The framework must be anchored on a farmer-centric approach that prioritizes the needs, perspectives, and experiences of farmers above all else. This foundational principle ensures that technology is designed for farmers' direct benefit, leading to wider adoption of resulting technologies and practices. To achieve this, the framework must be built on robust data privacy and security measures that protect farmer information while maintaining transparency in data collection and usage, coupled with accessibility and inclusivity standards that make AI/ML solutions available to all farmers regardless of their technological literacy or socioeconomic background. The framework should also emphasize ethical governance structures that respect user privacy and establish clear management protocols, while leveraging AI/ML to promote sustainable agricultural practices including resource conservation, climate adaptation, and environmental impact reduction. Success depends on fostering partnerships among researchers, policymakers, farmers, and technology providers, supported by open knowledge sharing that accelerates development and adoption. Finally, the system must be designed for continuous learning and improvement, incorporating user feedback and evolving data to ensure the AI/ML solutions remain relevant and effective over time.

Table 7. Monitoring and improvement strategies for national knowledge hubs

Recommendation	Component	Implementation Strategy
Monitoring, evaluation and adaptation	Continuous monitoring	Implement a pre-designed monitoring plan for daily knowledge delivery, and establish feedback mechanisms from users and stakeholders at all stages of the knowledge process.
	Periodic evaluation	Conduct regular evaluations to assess the K-Hub's efficiency and service delivery, including evaluation of user satisfaction, technical performance and the knowledge process.
	Performance indicators	Define performance indicators with relevant metrics for each stage of the knowledge process and assess the relationship between knowledge processes.
	Data segregation	Implement data segregation measures for ease of communication and evaluation of results
	Improvement cycle	Utilize evaluation results to inform adaptation and improvement decisions, identify strengths and weaknesses based on user experiences, plan improvements, and update the monitoring framework accordingly.
	Reporting and communication	Document evaluations in periodic reports and timely communication of updates to all users/stakeholders to ensure the use of updated services
	Implementation	The knowledge hub management board is responsible for overseeing this monitoring and evaluation, with annual review of this policy for continuous improvement and adaptation.



5.1.2 Specific principles

Beyond the core guiding principles, specific implementation principles ensure that AI/ML solutions are contextually relevant and effective in agricultural knowledge hubs. These solutions must be tailored to specific agro-ecological conditions and individual farmer needs while incorporating traditional knowledge and local practices to enhance applicability and acceptance. The systems should seamlessly integrate with existing K-Hub platforms through robust interoperability standards, supported by high-quality, unbiased data and appropriate governance practices that maintain data integrity throughout the AI/ML model training process. To ensure long-term viability, the framework must implement comprehensive cybersecurity measures and develop contingency plans for potential system failures or biases, while designing solutions that can scale efficiently with growing data volumes and user bases. The ultimate goal is knowledge democratization, leveraging AI/ML capabilities to make agricultural knowledge more accessible and understandable to diverse audiences by breaking down language and cultural barriers that traditionally limit knowledge sharing across different farming communities.

5.2 AI/ML Framework for Implementation

The AI/ML implementation framework for African agricultural knowledge hubs is structured around three interconnected domains: business, data and infrastructure, and people and culture.

5.2.1 Business

This business domain requires establishing clear strategic objectives and governance frameworks that align with operational needs through cross-functional representation, supported by comprehensive roadmaps that articulate vision, long-term goals, specific objectives, key initiatives, timelines, and resource requirements. The business framework must also address sustainability and scalability through diversified funding mechanisms including shared funding, public-private partnerships, tiered subscriptions, grants, and investments, while optimizing resource allocation and implementing robust financial management practices. Operational excellence within the business component depends on systematic performance measurement through key performance indicators and regular stakeholder feedback mechanisms, coupled with comprehensive risk assessment and mitigation strategies for AI/ML deployment. The framework emphasizes phased implementation approaches managed through dedicated project management offices, ensuring proper resource identification and allocation alongside comprehensive stakeholder engagement plans that facilitate smooth operational execution and long-term sustainability of AI/ML initiatives across agricultural knowledge hubs.

5.2.2 Data and infrastructure

The data and infrastructure component forms the technical backbone of AI/ML implementation in agricultural knowledge hubs, beginning with comprehensive data strategy development that assesses K-Hub data readiness and establishes frameworks for data sourcing, accuracy, privacy, security, governance, and regulatory compliance. This strategy must ensure data accessibility, availability, sharing capabilities, interoperability, and scalability while maintaining the highest standards of data integrity. Central to this approach is the development of knowledge graphs that structure and organize hub resources to create additional value through AI-enhanced searching, recommendation systems, and specialized AI-based applications that improve knowledge discovery and utilization. The infrastructure foundation requires robust technical resources including scalable storage systems, high-speed network infrastructure, data integration and quality management tools, high-end computing resources, and advanced analytics and visualization platforms supported by collaborative environments. Technology integration follows a systematic approach involving thorough needs assessment, development of tailored AI models, pilot testing in real-world agricultural scenarios, and responsible deployment that

adheres to ethical considerations while maintaining strict data privacy and security regulations throughout the implementation process.

5.2.3 People and culture

This component addresses the human dimension of AI/ML implementation by first establishing appropriate organizational structures through comprehensive capability assessments, strategic team structure definition, and decisions regarding insourcing versus partnership approaches for recruitment. This foundation supports clear role identification and responsibility delineation, ensuring that specific duties, expectations, and accountability areas are well-defined across all team members. The component emphasizes cultural transformation through change management strategies that promote an AI/ML-driven culture encouraging innovation and data-driven decision-making throughout the organization. Knowledge sharing and collaboration are facilitated through communities of practice that leverage sub-regional and regional networks, strategic partnerships, and collaborative models designed to maximize initiative reach and effectiveness. Skills development forms a critical pillar through tiered training programs, established AI/ML learning paths, mentorship programs, and regular skills assessments supported by dedicated learning budgets and access to online learning platforms and resources. This comprehensive approach ensures that human capital development keeps pace with technological advancement, creating a workforce capable of effectively implementing and managing AI/ML solutions in agricultural knowledge hubs.

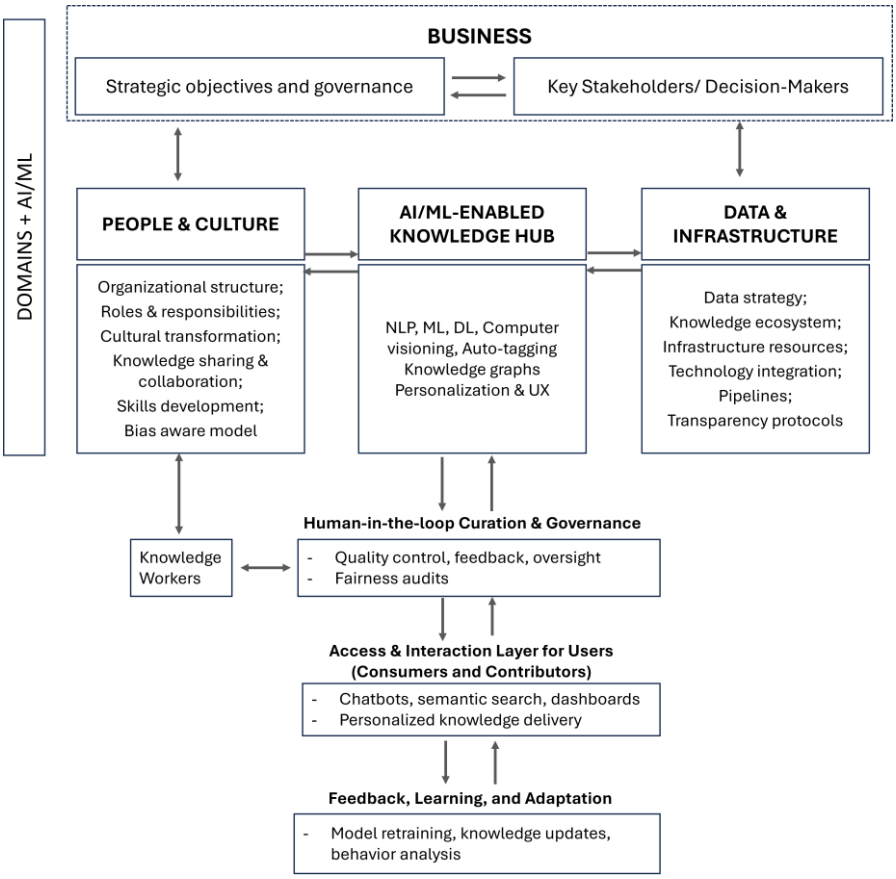


Figure 3. Conceptual Framework: AI/ML in Agricultural Knowledge Hubs
Source: Authors

The conceptual framework in Figure 3 illustrates how the integration of AI/ML into the knowledge hub is expected to interact with the organisation's core domains: Business, Data & Infrastructure, and People & Culture. The alignment of AI/ML systems with strategic business goals generates predictive insights, enhances decision-making and ensures governance within workflows. The Data & Infrastructure domain provides the technological backbone for effective data management to support intelligent systems. On the other hand, the People & Culture domain plays a pivotal role in the adoption of AI/ML technologies and building trust through learning, collaboration and human-in-the-loop practices. This framework suggests that integration of these domains with AI/ML technology can improve the adaptability, accessibility and inclusivity of agricultural knowledge hubs in Africa in reaching the last mile and addressing growing knowledge challenges within the continent's agricultural sector.

6 Conclusions and recommendations

To establish a national agricultural knowledge hub, it is essential to begin with a clear vision and well-defined objectives, supported by a policy framework that aligns with the country's broader agricultural development goals. This effort must be grounded in inclusive stakeholder engagement, bringing together actors from government, academia, the farming community, industry, and civil society. A solid foundation in both digital and physical infrastructure is critical, with scalability built in from the start to accommodate future growth. Alongside infrastructure, a comprehensive approach to data, information, and knowledge management should be implemented to ensure efficient capture, organization, and dissemination of agricultural knowledge. The success of such a hub also depends on assembling a competent core team and committing to ongoing training and skills development. Governance structures and operational policies must be clearly articulated to guide the hub's work. Furthermore, sustainable funding models which draw on a mix of government support, private-sector partnerships and revenue-generating activities, are key to ensuring long-term viability. Outreach initiatives will help cultivate public awareness and strengthen community engagement with the hub.

In parallel, the integration of artificial intelligence and machine learning (AI/ML) into agricultural knowledge hubs should follow a strategic road map that reflects the hub's goals. This integration must be grounded in strong ethical principles and transparent governance. High-quality, unbiased datasets should be prioritized for training AI/ML models, which must also be designed to interoperate with existing systems and tools. Cybersecurity is another crucial aspect, requiring strong measures to protect both systems and user data. AI/ML technologies should not only enhance accessibility but also improve comprehension and application of agricultural knowledge, especially among underserved communities. A phased, iterative approach to implementation—coupled with regular performance evaluations—can help ensure that AI/ML tools evolve responsively. Building an internal culture that embraces digital innovation and investing in the development of AI/ML skills among staff through targeted training and partnerships will also be essential for success.

Addressing the current challenges facing knowledge hubs will require several coordinated efforts. Data quality and availability must be improved through better community engagement and standardized methods for data collection. Investment in modern technological infrastructure is necessary to support advanced digital tools, particularly in rural areas where connectivity remains limited. Designing user-friendly systems and providing training to improve adoption will help ensure broad participation. Equally important is the implementation of strong data privacy and security measures to build trust among users.

Collaboration and knowledge sharing are central to the effectiveness of knowledge hubs. Establishing linkages and partnerships with other hubs, both nationally and internationally, can facilitate the exchange of insights and resources. Creating communities of practice focused on the implementation of AI/ML technologies will further enable learning and innovation. These communities can also support collaborative research and program development with various stakeholders.

Monitoring and continuous improvement are critical to sustaining hub performance. This involves establishing systems for routine monitoring and periodic evaluation, with clearly defined performance indicators for each phase of the knowledge process. Insights from these evaluations should be used to inform ongoing adaptation and improvement efforts.

Finally, securing long-term funding and ensuring sustainability must be a top priority. A diversified funding strategy—combining government allocations, external grants, partnerships, and income-generating activities—will help reduce reliance on any single source. Developing sustainable business models, including subscription-based access or data monetization, can further bolster financial resilience. The establishment of endowment funds may also provide the stability needed to support the hub's long-term operations.

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About the authors

Oluwaseun Bolarinwa AKINYEMI is a Researcher and knowledge manager at the Agricultural Research Council of Nigeria (ARCN) with a strong background in knowledge management, data science, and digital innovation in agricultural research systems. A certified knowledge manager, he has played a pivotal role in shaping national policies, including the Gender Policy, and developed the first zero-draft knowledge management strategy and policy for Nigeria's National Agricultural Research System (NARS). With a Master's in Information Science and certificates in Data Science, Marketing, and Management, he is skilled in R, Python, SQL, Git, AI/ML, actively applying his skills to democratize knowledge and foster Communities of Practice.
Email: akinyemi.oluwaseun.b@gmail.com; o.akinyemi@arcn.gov.ng

Emmanuel Amek AKOTO is an ICT Specialist and Data Analyst with over 20 years of experience in systems integration, IT governance, web applications, and data analytics across government, private, and international sectors. A Certified Knowledge Management Practitioner and member of the KM4AgD Community of Practice, with a special focus on the development and optimization of knowledge hubs. His work explores how AI and ML can enhance the efficiency and effectiveness of these hubs. Amek's professional journey is driven by a commitment to bridging agriculture and emerging technologies. He applies digital tools to boost agricultural research adoption, enhancing productivity and smallholder livelihoods. He has developed data systems and led ML projects for crop health and cocoa bean quality. As Executive Director of CICS Technologies and GreenWeb Consult in Ghana, he leads AgTech initiatives that empower stakeholders across the agricultural value chain.
Email: ameque@gmail.com

Bosede Adeyinka AYINLA is an Information Systems Specialist at the International Institute of Tropical Agriculture (IITA) Knowledge Centre, Nigeria, with over 15 years of professional experience as a practising librarian and knowledge management expert. She holds a Doctor of Philosophy degree in the Application of Electronic Media Technologies to Libraries' Operations and Reading from the Department of School Library and Media Technology, University of Ibadan, Nigeria. Dr Ayinla also earned her first degree in Library, Archival and Information Studies and a second degree in Information Science from the University of Ibadan. A certified knowledge manager, Dr. Ayinla's work focuses on advancing the use of Information and Communication Technologies (ICTs) in libraries and research knowledge centres. In her role at IITA, she contributes to building effective knowledge systems and networks that support research excellence and institutional learning.
Email: b.ayinla@cgiar.org

Narcisse YEHOUENOU is a Data Scientist and Certified Knowledge Manager specializing in environmental science and sustainable agriculture. Currently a PhD candidate at the University for Development Studies (UDS) in Ghana, his research focuses on the environmental impacts of agricultural sustainable intensification. He is a research fellow at the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) and an active member of ICT4U-NGO in Benin. Yehouenou earned a Master of Research in Biostatistics from the University of Abomey-Calavi (UAC) in Benin.

Email: narcisstar211@gmail.com; yehouenou.n@wascal.org

Kgothatso Lovey TSHIPO is a Knowledge Management specialist with a Bachelor's Degree in Information and Knowledge Management (Knowledge Management) attained at the University of Botswana and is also a Certified Knowledge Manager for Sustainable Agriculture. She has worked at the National Agricultural Research and Development Institute (NARDI) in Botswana, where she contributed to the building of an expert and farmer database for knowledge sharing and fostering of collaboration between stakeholders in Agriculture. Kgothatso now works as a member of the Assistant Minister's core team at the Ministry of Water and Human Settlement in Botswana.
Email: kltshipo@gov.bw

Guy Marius ASSOGBA is a Senior Research Associate working on Climate-Smart Agriculture (CSA) and the scaling of innovations at the Alliance of Bioversity International and CIAT in Dakar, Senegal. Previously, he served as Senior Officer for Training, Information, and Communication at the Ministry of Agriculture, Fisheries, and Livestock in Benin. He holds an Agronomy Engineering degree from the University of Abomey-Calavi and a Master degree in Hydraulic Engineering – Land and Water Development from IHE Delft. He is also a certified Knowledge Manager by the Forum for Agricultural Research in Africa (FARA).
Email: g.assogba@cgiar.org

Israel NON-NDE DJIDAINAIRI is an Agroeconomist and currently serves as Program Head for Macroeconomics, Rural Economy, and Sociology at the Chadian Institute of Agronomic Research for Development (ITRAD). An expert in agricultural knowledge management, he is pursuing a PhD in agroeconomics at Nazi Boni University in Burkina Faso, where he is a researcher at the Laboratory of Rural Studies on Environment and Economic and Social Development. His expertise spans food security, sustainable development, Climate-Smart Agriculture (CSA), and Participatory and Integrated Climate Services for Agriculture (PICSA). He has strong skills in agricultural policies, agri-food value chains, and project cycle management. Rigorous and methodical, Mr. DJIDAINAIRI combines excellent analytical abilities, strong interpersonal and writing skills, and familiarity with results-based management.
Email: djidainairi.israel@itrad.td, isosnonda11@gmail.com

Ishmael Kgosietsile MAIKANO is an information specialist, (Librarian). With basic knowledge in Intellectual property rights and Patent Search by World Intellectual Property Organisation (WIPO) and currently managing the Resource Centre at the National Agricultural Research and Development Institute (NARDI)of Botswana, a member of CCARDESA, and a certified Knowledge Manager by the Forum for Agricultural Research in Africa (FARA).
Email: ishmaelmaikano@gmail.com

References

Abugri, B., & Brandner, A. (2021). Continental data capture strategy: A practical guide for knowledge managers in Africa AR4D. Forum for Agricultural Research in Africa (FARA).

AFAAS. (2022). CAADP-XP4 implementation report. AFAAS Secretariat.

AFAAS. (2023). AFAAS Knowledge Hub overview. https://khub.afaas-africa.org

AGRA. (2017). Africa Agriculture Status Report: The Business of Smallholder Agriculture in Sub-Saharan Africa (Issue 5). Alliance for a Green Revolution in Africa (AGRA). https://agra.org/wp-content/uploads/2017/09/Final-AASR-2017-Aug-28.pdf

Aijaz, N., Lan, H., Raza, T., Yaqub, M., Iqbal, R., & Pathan, M. S. (2025). Artificial intelligence in agriculture: Advancing crop productivity and sustainability. *Journal of Agriculture and Food Research*, 20, 101762. https://doi.org/10.1016/j.jafr.2025.101762

Akosombo Integration Agenda. (2022). A scan on knowledge management in Ghana's agricultural sector. https://accessagric.com/a-scan-on-knowledge-management-in-ghanas-agricultural-sector/

Alemdar, H., & Érger, S. (2022). Artificial Intelligence for Sustainable Agriculture: A Comprehensive Review of Precision Farming Applications. Sustainability, 17(5), 2281. https://doi.org/10.3390/su17052281

Andreev, I. (2025, April 7). Knowledge management: Importance, benefits, examples. Valamis. https://www.valamis.com/hub/knowledge-management

ASARECA. (2022). CAADP-XP4 annual technical report. ASARECA Secretariat.

ASARECA. (2023). ASARECA Knowledge Hub overview. https://www.asareca.org

ASARECA. (2025). About Knowledge Hub. ASARECA KI-Hub.

Bollinger, A. & Smith, R. (2001). Managing Organizational Knowledge as a Strategic Asset. *Journal of Knowledge Management*. 5. 8-18. 10.1108/13673270110384365.

Brar, J., Chowdhury, N., Raihan, M. M. H., Khalid, A., O'Brien, M. G., Walsh, C. A., & Turin, T. C. (2023). The benefits, challenges, and strategies toward

establishing a community-engaged knowledge hub: An integrative review. *International Journal of Environmental Research and Public Health*, 20(2), 1160. https://doi.org/10.3390/ijerph20021160

CCARDESA. (2022). Annual technical report – CAADP-XP4 implementation. CCARDESA Secretariat.

CCARDESA. (2023). CCARDESA Knowledge Hub overview. https://www.ccardesa.org/knowledge-hub

CGIAR. (2009). CGSpace: Making CGIAR knowledge open. https://cgspace.cgiar.org

Chambers, R., Pacey, A., & Thrupp, L. A. (Eds.). (1989). Farmer first: Farmer innovation and agricultural research. Intermediate Technology Publications. https://doi.org/10.3362/9781780440149

Chapman, A. (2025). *How Poor Data Governance Sabotages AI Initiatives*. AI Talent Flow. Retrieved from https://aitalentflow.com/poor-data-governance-sabotages-ai-initiatives/

Chen, L., Xu, Y., & Wang, X. (2024). The role of large language models in personalized learning: A systematic review of educational impact. Discover Sustainability, 6(1). https://doi.org/10.1007/s43621-025-01094-z

Cummings, S., White, N., Schoenmakers, M., van Reijswoud, V., Koopman, M., Zielinski, C., Mugarura, C., Assa, R., & Harish, S. (2019). Checklist for the development of portals for international development. *Knowledge Management for Development Journal*, 14(1), 83–94. https://www.km4djournal.org/index.php/km4dj/article/download/384/561

David, P. A., & Foray, D. (2003). Economic fundamentals of the knowledge society. *Policy Futures in Education*, 1(1), 20–49. https://doi.org/10.2304/pfie.2003.1.1.7

Dymling, S. (2024). *The Dangers of Poor Data Quality in AI Systems*. Twoday. Retrieved from https://www.twoday.com/blog/the-dangers-of-poor-data-quality-in-ai-systems.

Evers, H. D. (2008). Knowledge hubs and knowledge clusters: Designing a knowledge architecture for development. *MPRA Paper, 8778*. University Library of Munich, Germany. https://ideas.repec.org/p/pra/mprapa/8778.html

Evers, H., Gerke, S. and Menkhoff, T. (2010), "Knowledge clusters and knowledge hubs: designing epistemic landscapes for development", *Journal of Knowledge Management*, Vol. 14 No. 5, pp. 678-689. https://doi.org/10.1108/13673271011074836

Evers, H.-D., Gerke, S., & Menkhoff, T. (2011). Knowledge hubs and knowledge clusters: A knowledge architecture for development. https://doi.org/10.1142/9789814343688_0002

Food and Agriculture Organization (FAO). (2014). The role of agricultural knowledge and innovation systems in fostering agricultural productivity and sustainable rural development in developing countries. http://www.fao.org/3/i3761e/i3761e.pdf

Food and Agriculture Organization (FAO). (2020). The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets. http://www.fao.org/publications/sofi/en/

Food and Agriculture Organization (FAO). (2022). The state of food and agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems. https://doi.org/10.4060/cb9479en

Food and Agriculture Organization (FAO). (2025). Data in Emergencies (DIEM) Hub: Bridging data and action for agricultural resilience [Briefing note]. https://data-in-emergencies.fao.org

Forum for Agricultural Research in Africa (FARA). (2020). Akosombo Integration Agenda for knowledge management in Africa: Continental data capture strategy (CDCS). https://faraafrica.org

Forum for Agricultural Research in Africa (FARA). (2021). Accra Declaration: Knowledge Management for Agricultural Development (KM4AgD) Agenda. https://faraafrica.org

Forum for Agricultural Research in Africa (FARA). (2024). About the FARADataInformS Knowledge Hub [Internal document].

Gabriele, R., D'Ambrosio, A., & Schiavone, F. (2017). Open innovation and the role of hubs of knowledge in a regional context. *Journal of the Knowledge Economy*, 8, 1049–1065. https://doi.org/10.1007/s13132-015-0331-y

Goyal, A. (2010). Information, direct access to farmers, and rural market performance in Central India. *American Economic Journal: Applied Economics*, 2(3), 22–45. https://doi.org/10.1257/app.2.3.22

Hussein, A. T. T., Singh, S. K., Farouk, S., & Sohal, A. S. (2016). *Knowledge sharing enablers, processes, and firm innovation capability*. *Journal of Workplace Learning, 28*(8), 484-495. Emerald Insight

Indiveri, G., & Liu, S.-C. (2015). Memory and information processing in neuromorphic systems. *Proceedings of the IEEE*, 103(8), 1379–1397. https://doi.org/10.1109/JPROC.2015.2444094

Intergovernmental Panel on Climate Change (IPCC). (2019). Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl/

International Food Policy Research Institute (IFPRI). (2018). Global Food Policy Report 2018. https://doi.org/10.2499/9780896292970

International Fund for Agricultural Development. (2024). The field report. https://www.ifad.org/thefieldreport

International Telecommunication Union. (2020). The last-mile Internet connectivity solutions guide: Sustainable connectivity options for unconnected sites. ITU. International Telecommunication Union (ITU). (2020). The Last-mile Internet Connectivity Solutions Guide. ITU-D Technology and Network Development. https://www.itu.int/en/ITU-D/Technology/Pages/LMC/LMC-Home.aspx

Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. *Science*, 349(6245), 255–260. https://doi.org/10.1126/science.aaa8415

Kakuwa-Kasongamullio, B. (2024, April 10). CCARDESA communication channels & reaching the last mile [Conference presentation]. CCARDESA, Gaborone, Botswana.

Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2017). A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture*, 143, 23–37. https://doi.org/10.1016/j.compag.2017.09.037

Klerkx, L., van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: Concepts, analysis, and interventions. In I. Darnhofer, D. Gibbon, & B. Dedieu (Eds.), Farming systems research into the 21st century: The new dynamic (pp. 457–483). Springer. https://doi.org/10.1007/978-94-007-4503-2_20

Knowledge Management for Agricultural Development (KM4AgD). (2021). Accra Declaration: First Continental Conference on Knowledge Management for Agricultural Development.

Leeuwis, C., & Aarts, N. (2011). Rethinking communication in innovation processes: Creating space for change in complex systems. *Journal of Agricultural Education and Extension*, 17(1), 21–36. https://doi.org/10.1080/1389224X.2011.536344

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors*, 18(8), 2674. https://doi.org/10.3390/s18082674

Lihasi, L. (2024). African Forum for Agricultural Advisory Services (AFAAS) knowledge management strategy [PowerPoint presentation]. KM4AgD Challenge 2024, AFAAS. https://www.afaas-africa.org

Mishra, H., & Divyanshi M. (2023). Artificial Intelligence and Machine Learning in Agriculture: Transforming Farming Systems. In Research Trends in Agriculture Science Volume I (pp. 1–16). Zenodo. https://doi.org/10.5281/zenodo.15157536

Organisation for Economic Cooperation and Development (OECD). (2019). *Recommendation of the Council on Artificial Intelligence (OECD-LEGAL-0449)*. OECD Legal Instruments. https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449#adherents

Organisation for Economic Cooperation and Development (OECD). (2013), *Agricultural Innovation Systems: A Framework for Analysing the Role of the Government*, OECD Publishing, Paris, https://doi.org/10.1787/9789264200593-en.

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P., & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability, 1*(8), 441–446. https://doi.org/10.1038/s41893-018-0114-0

Rashid, A. B., & Kausik, M. A. K. (2024). AI revolutionizing industries worldwide: A comprehensive overview of its diverse applications. *Hybrid Advances*, 7, 100277. https://doi.org/10.1016/j.hybadv.2024.100277

Ray, S. N. (2025). *Challenges and solutions in data integration for heterogeneous systems*. ResearchGate. https://www.researchgate.net/publication/391161257

Russell, S. J., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.

Saravanan, K. S., & Bhagavathiappan, V. (2024). Innovative agricultural ontology construction using NLP methodologies and graph neural network. *Engineering Science and Technology, an International Journal*, *52*, 101675. https://doi.org/10.1016/j.jestch.2024.101675

Schwab, K. (2017). *The Fourth Industrial Revolution*. Crown Business.

Singh, N., Wang'ombe, J., Okanga, N., Zelenska, T., Repishti, J., Jayasankar, K., Mishra, S., Manokaran, R., Singh, V., Rafiq, M., Gandhi, R., & Nambi, A. (2024). *Farmer.Chat: Scaling AI-Powered Agricultural Services for Smallholder Farmers*. arXiv: DOI:10.48550/arXiv.2409.08916. https://arxiv.org/pdf/2409.08916

Somasundaram, P. (2023). The power of organizational learning and collaboration with knowledge management. Document360. https://document360.com/blog/organizational-learning-with-knowledge-management/

Statista. (2024, May 7). Internet penetration rate worldwide 2024, by region. *Statista*. https://www.statista.com/statistics/269329/penetration-rate-of-the-internet-by-region/

Stiglitz, J. E. (1999). 'Knowledge as a Global Public Good', in Inge Kaul, Isabelle Grunberg, and Marc Stern (eds), *Global Public Goods: International Cooperation in the 21st Century* (New York, 1999; online

edn, Oxford Academic, 1 Nov. 2003), https://doi.org/10.1093/0195130529.003.0015.

Sylvester, G. (2017). *Success stories on information and communication technologies for agriculture and rural development* (2nd ed.). Food and Agriculture Organization of the United Nations (FAO). https://openknowledge.fao.org/handle/20.500.14283/i6733en

Trendov, N. M., Varas, S., & Zeng, M. (2019). Digital technologies in agriculture and rural areas: Status report. Food and Agriculture Organization of the United Nations.

Tsan, M., Totapally, S., Hailu, M., & Addom, B. K. (2019). *The Digitalisation of African Agriculture Report 2018–2019*. CTA/Dalberg Advisers. https://hdl.handle.net/10568/101498

United Nations Economic Commission for Africa (UNECA). (2021). *AI in Africa: opportunities, challenges and policy considerations*. Addis Ababa. UNECA,. https://hdl.handle.net/10855/48193

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda

University College London (UCL) (2022). *Policy brief: Neuromorphic computing: Enabling a future AI world.* UCL Engineering. https://www.ucl.ac.uk/engineering/policy-brief-neuromorphic-computing-enabling-future-ai-world-0

Van Paassen, A., Klerkx, L., Adu-Acheampong, R., Adjei-Nsiah, S., Ouologuem, B., Zannou, E., ... & Traore, M. (2013). Choice-making in facilitation of agricultural innovation platforms in different contexts in West Africa: Experiences from Benin, Ghana and Mali. *Knowledge Management for Development Journal*, 9(3), 79–94.

Victor, M. (2024, May 7). A KM approach to communications and advocacy [Conference presentation]. KM4AgD Challenge 2024, International Livestock Research Institute (ILRI), Nairobi, Kenya.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2017). Big data in smart farming – A review. *Agricultural Systems*, 153, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

World Bank (2012). Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank Publication. http://hdl.handle.net/10986/2247

World Bank (2020). Poverty and Shared Prosperity 2020: Reversals of Fortune. World Bank Publication. http://hdl.handle.net/10986/34496

Wu, Y., Schuster, M., Chen, Z., Le, Q. V., Norouzi, M., Macherey, W., ... & Dean, J. (2016). Google's neural machine translation system: Bridging the gap between human and machine translation. *arXiv preprint arXiv:1609.08144*. https://arxiv.org/abs/1609.08144

Yerramareddy, I., & Babu, S. C. (2018). Knowledge and data: Achieving food and nutrition security through open access data. In: Global food policy report 2018 (pp. 56–67). IFPRI. https://doi.org/10.2499/9780896292970_06

1 https://km4agd.faraafrica.org/
2 https://cgspace.cgiar.org/home
3 https://datainforms.faraafrica.org/
4 https://khub.afaas-africa.org
5 https://www.knowledgehub.ccardesa.org/
6 https://khub.asareca.org/kihub/
7 https://mita.coraf.org/index.php?p=home&lang=fr
8 https://feserwam.org/fr/accueil-2/