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Harmonizing Ghana's Digital Agriculture Ecosystem: Pathways for Coordination, Uptake, and Sustainability of CGIAR-Supported Innovations

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Key messages

- Ghana is rapidly building an integrated climate-smart digital agriculture ecosystem that combines climate-information services, interoperable data systems, AI-enabled agronomic intelligence, and farmer-facing advisory platforms to strengthen agricultural resilience and climate adaptation.
- The Ghana Agricultural Innovation and Data Hub (AIDH) serves as the interoperability backbone of the ecosystem by linking digital agriculture platforms, extension systems, visualization tools, and emergency-response systems through federated data exchange and integrated dashboards.
- Innovations such as AgWise, HingaSmart, Esoko, the Cropping Calendar and Digital Advisory Decision Support Tool (DST), and the Climate Risk Management in Agricultural Extension (CRMAE) curriculum demonstrate how climate intelligence can be operationalized through integrated advisory, extension, and decision-support systems.

Digital transformation in agriculture is rapidly accelerating in Ghana through the emergence of interoperable agricultural data systems, climate-information services, AI-enabled agronomic intelligence platforms, irrigation and water-management tools, digital extension systems, and climate-smart advisory services (Restrepo et al., 2023; Ewell et al., 2025). CGIAR centres—including the Alliance of Bioversity International and CIAT, International Water Management Institute (IWMI), International Institute of Tropical Agriculture (IITA), and associated partners—have played a major role in supporting this transformation through innovations that strengthen climate resilience, advisory delivery, precision agronomy, and evidence-based agricultural planning (Wilson et al., 2023; Mvuyibwami et al., 2023; Abera et al., 2025; Akpoti et al., 2026).

However, the proliferation of digital agriculture systems has also created increasing fragmentation. Innovations developed through different projects and institutional arrangements often operate in parallel rather than through harmonized and

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interoperable systems (Otieno et al., 2026). Several platforms target overlapping users, advisory pathways, and dissemination systems, while institutional mandates for hosting and scaling remain distributed across ministries, research institutions, private-sector actors, and extension systems (List et al., 2023; Trzaska et al., 2023).

Without deliberate harmonization, interoperability, institutional anchoring, and scaling pathways, these innovations risk duplication of effort, fragmented data governance, and limited long-term sustainability (Otieno et al., 2026; Ewell et al., 2025).

In response, this InfoNote examines Ghana's emerging digital agriculture ecosystem and explores pathways for coordination, interoperability, government uptake, and institutional mainstreaming across CGIAR-supported innovations.

In particular, this InfoNote:

- maps major CGIAR-supported digital agriculture and climate-information innovations in Ghana;
- analyses complementarities and overlap across innovations;
- identifies opportunities for harmonization and interoperability;
- examines extension and institutional mainstreaming pathways; and
- outlines opportunities for long-term government uptake and sustainability.

Methods

This InfoNote draws upon a rapid landscaping exercise of CGIAR-supported digital agriculture and climate-information innovations operating within Ghana's agricultural sector. The assessment considered innovations spanning climate-information services, agro-advisory systems, irrigation and water-resource intelligence, digital extension systems, agricultural data infrastructure, AI-enabled agronomic intelligence, visualization systems, and extension-capacity development initiatives (Restrepo et al., 2023; Ewell et al., 2025).

Key innovations were identified through review of Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA), Excellence in Agronomy (EiA), Sustainable Farming Science, and Transforming Agrifood Systems in West and Central Africa Initiative (TAFS-WCA) documentation, alongside technical reports, workshop reports, InfoNotes, visualization tools, digital platforms, GitHub repositories, and multimedia resources (Wilson et al., 2023; Mvuyibwami et al., 2023; Abera et al., 2025; List et al., 2023; Trzaska et al., 2024). Information was consolidated for each innovation, including functionality, implementing partners, institutional arrangements, scaling pathways, interoperability potential, advisory functions, and target users (Otieno et al., 2026; Ewell et al., 2025).

The analysis examines complementarities, overlaps, dissemination pathways, extension-system integration, and institutional hosting opportunities across the ecosystem. Particular attention was given to the role of interoperable agricultural data systems, AI-enabled decision-support architectures, climate-risk management systems, and extension-capacity development in supporting long-term sustainability and climate-smart agricultural transformation (Wilson et al., 2024; Abera et al., 2025; Tibebe et al., 2025; Grossi, 2023).

Ghana's Digital Agriculture and Climate-Information Landscape

Ghana's agricultural system is increasingly shaped by digitalization through the expansion of climate-information services, AI-enabled agronomic intelligence systems, interoperable agricultural data infrastructure, digital extension systems, irrigation and water-management platforms, visualization tools, and farmer-facing advisory services (Restrepo et al., 2023; Ewell et al., 2025). Digital innovations now support a wide spectrum of functions, including climate-risk management, agro-advisories, crop planning, irrigation investment, reservoir monitoring, extension coordination, emergency response systems, agricultural visualization, and evidence-based planning (Wilson et al., 2023; Wilson et al., 2025; Akpoti et al., 2025; Inusah & Abera, 2024).

This rapid expansion is consistent with broader continental and regional trends emphasizing digital agriculture, climate-smart advisory systems, interoperable agricultural data systems, and climate-informed decision-making (Restrepo et al., 2023). CGIAR-supported innovations have played an important role in shaping this ecosystem through partnerships involving government agencies, research institutions, private-sector actors, extension systems, and development partners (Mvuyibwami et al., 2025; Otieno et al., 2026; Grossi, 2023).

The mapped innovations highlight three important dynamics:

1. Rapid growth in digital agriculture systems

Ghana's digital agriculture landscape is becoming increasingly dense, with multiple CGIAR-supported tools now operating across climate-information services, AI-enabled agronomic intelligence, agro-advisory dissemination, irrigation planning, extension systems, and visualization architectures (Restrepo et al., 2023; Ewell et al., 2025). Innovations such as the Ghana Agricultural Innovation and Data Hub (AIDH), AgWise, HingaSmart, Esoko, the Cropping Calendar and Digital Advisory Decision Support Tool (DST), IRRILINE, and the IWMI Small Reservoirs Dashboard (SWaRD) collectively demonstrate the rapid expansion of digital climate-smart agriculture systems (Wilson et al., 2023; Abera et al., 2025; Mvuyibwami et al., 2025; Kyeremeh & Koi, 2023a; Wilson et al., 2025; IRRILINE: A new service from Farmerline, n.d.; Akpoti et al., 2025).

2. Fragmented architectures and overlapping systems

Despite significant innovation growth, many platforms continue to operate through separate hosting systems, datasets, dissemination pathways, institutional arrangements, and advisory channels (Otieno et al., 2026). Several innovations target overlapping users, extension systems, and climate-advisory functions across climate-information services, agro-advisory dissemination, and digital extension systems (Restrepo et al., 2023; Ewell et al., 2025). This fragmentation can increase operational costs, complicate data governance, duplicate dissemination systems, and limit long-term sustainability (Otieno et al., 2026; List et al., 2023).

The ecosystem additionally involves multiple actors—including the Ministry of Food and Agriculture (MoFA), Ghana Meteorological Agency (GMet), Council for Scientific and Industrial Research (CSIR), International Water Management Institute (IWMI), Alliance of Bioversity International and CIAT, International Institute of Tropical Agriculture (IITA), Esoko, Farmerline, universities, and extension systems—each operating under different institutional mandates and technical architectures (Wilson et al., 2023; Mvuyibwami et al., 2025; Trzaska et al., 2023; Grossi, 2023).

3. Strong foundation for interoperability and institutional integration

Despite fragmentation challenges, Ghana possesses a strong institutional foundation for harmonization and interoperability (Otieno et al., 2026; Ewell et al., 2025). The Ghana Agricultural Innovation and Data Hub (AIDH) increasingly functions as an interoperability backbone capable of linking digital agriculture systems, visualization platforms, advisory services, and extension architectures through federated data exchange systems and integrated dashboards (Wilson et al., 2023; Wilson et al., 2024; Tepa et al., 2025; Ghana Agricultural Innovation and Data Hub, n.d.).

At the same time, initiatives such as the Climate Risk Management in Agricultural Extension (CRMAE) curriculum could provide the human-capacity and institutional layer necessary for mainstreaming digital agriculture and climate-information systems into extension structures and government service delivery systems (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023). Together, these developments create opportunities for long-term institutional anchoring, government uptake, interoperable digital public infrastructure, and coordinated climate-smart agricultural transformation (Otieno et al., 2026; Ewell et al., 2025).

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No.	Innovation Name	Type of Technology	Lead CGIAR Organization	CGIAR / Partner Involvement	Project(s) Supporting the Innovation	Project Status	Target Users	Region(s) Covered	Purpose / Functionality	Status	Hosting Government Institution(s)
1	Ghana Agricultural Innovation and Data Hub (AIDH)	Interoperable agricultural data platform	Alliance of Bioversity International and CIAT	CGIAR-led with MoFA, GMet, CSIR and partners	AICCRA	Ongoing	Government agencies, planners, extension systems, researchers	National	Integrated agricultural data management, dashboards, emergency response coordination, interoperability and agricultural intelligence	Ongoing	Ministry of Food and Agriculture (MoFA)
2	AgWise	AI-enabled agronomic intelligence platform	International Institute of Tropical Agriculture (IITA)	CGIAR-led multi-partner initiative	Excellence in Agronomy (EiA), Sustainable Farming Science	Ongoing	Farmers, extension officers, researchers, planners	National	Site-specific agronomic recommendations, climate analytics, fertilizer optimization, planting-date advisory, AI-enabled decision support	Ongoing	Not yet identified
3	HingaSmart	Agro-climate advisory platform	Alliance of Bioversity International and CIAT	CGIAR-led with national and private-sector partners	AICCRA	Ongoing	Farmers, extension officers, advisory-service providers	Northern Ghana / expanding nationally	Dissemination of climate-smart agro-advisories and climate-risk information	Ongoing	Ministry of Food and Agriculture (MoFA)
4	Cropping Calendar and Digital Advisory Decision Support Tool (DST)	Climate-smart agronomic advisory platform	Alliance of Bioversity International and CIAT	CGIAR-led with MoFA and partners	Sustainable Farming Science, AICCRA	Ongoing	Farmers, extension officers	Northern Ghana	Localized crop-management guidance, planting schedules, bundled agro-advisories	Ongoing	Ministry of Food and Agriculture (MoFA)
5	Esoko	Digital advisory dissemination system	Alliance of Bioversity International and CIAT	Private-sector partnership with Esoko	AICCRA	Ongoing	Farmers, extension officers	National	SMS dissemination, climate advisories, call-center support, bundled digital advisory services	Ongoing	Ministry of Food and Agriculture (MoFA)
6	IRRILINE	Irrigation advisory and investment platform	International Water Management Institute (IWMI)	CGIAR-private sector partnership with Farmerline	AICCRA	Pilot	Smallholder irrigation users, farmers	Northern Ghana	Irrigation planning, irrigation investment guidance, water-management advisory services	Pilot	Ghana Irrigation Development Authority (GIDA)
7	IWMI Small Reservoirs Dashboard (SWaRD)	Water-resource intelligence and visualization platform	International Water Management Institute (IWMI)	CGIAR-led with national water-resource partners	Sustainable Animal and Aquatic Foods (SAAF)	Ongoing	Water-resource planners, irrigation managers, researchers	National	Reservoir monitoring, waterbody analytics, irrigation and aquatic-food-system planning	Ongoing	Ghana Irrigation Development Authority (GIDA)
8	CIS-CSA Visualization Tool	Spatial visualization and planning platform	Alliance of Bioversity International and CIAT	CGIAR-led	AICCRA	Ongoing	Government agencies, donors, planners	National	Mapping and visualization of climate-smart agriculture interventions	Ongoing	Ministry of Food and Agriculture (MoFA)

9	Climate Risk Management in Agricultural Extension (CRMAE) Curriculum	Extension-training and climate-risk management curriculum	Columbia University / CGIAR partners	CGIAR-led with MoFA and extension-training institutions	AICCRA	Ongoing	Extension officers, universities, agricultural colleges	National	Climate-risk management training, climate literacy, advisory-system strengthening	Ongoing	Ministry of Food and Agriculture (MoFA) / Agricultural training institutions

Table 1: *CGIAR-Supported Innovations in Ghana*

Innovations Grouped by Target Users

The nine mapped innovations in Ghana's digital agriculture ecosystem serve a wide range of users operating at different decision-making levels across climate services, extension systems, irrigation planning, agronomic intelligence, water management, and agricultural governance (Restrepo et al., 2023; Ewell et al., 2025). Grouping these innovations according to their primary user groups helps illustrate how they collectively support climate-smart agriculture, where overlap exists, and where opportunities for harmonization and interoperability are emerging (Otieno et al., 2026).

These user categories—including government agencies, extension officers, farmers, researchers and training institutions, and multi-sectoral planners—form a functional ecosystem extending from upstream climate and agricultural intelligence generation to downstream advisory dissemination, institutional learning, and long-term capacity strengthening (Wilson et al., 2023; Abera et al., 2025; Trzaska et al., 2024; Grossi, 2023).

National Agencies and Actors

Ghana's digital agriculture and climate-information ecosystem is anchored in a set of national institutions responsible for climate services, agricultural extension, agricultural research, irrigation planning, disaster-risk management, and national digital governance (Restrepo et al., 2023; Ewell et al., 2025). Institutions such as the Ministry of Food and Agriculture (MoFA), Ghana Meteorological Agency (GMet), Council for Scientific and Industrial Research (CSIR), Plant Protection and Regulatory Services Directorate (PPRSD), and associated research and planning institutions increasingly depend on digital platforms that provide climate analytics, agricultural intelligence, extension coordination, visualization systems, and interoperable data infrastructure (Wilson et al., 2023; Otieno et al., 2026; Trzaska et al., 2024).

Innovations supporting this user group include:

- the Ghana Agricultural Innovation and Data Hub (AIDH), which supports interoperable agricultural data management, integrated dashboards, emergency-response coordination, and agricultural innovation management (Wilson et al., 2023; Wilson et al., 2024; Tepa et al., 2025; Ghana Agricultural Innovation and Data Hub, n.d.);
- AgWise, which provides AI-enabled agronomic intelligence, probabilistic climate analytics, fertilizer optimization systems, and forecast-based advisory generation (Abera et al., 2025; Ahmed et al., 2025; Tibebe et al., 2025);
- the IWMI Small Reservoirs Dashboard (SWaRD), which supports water-resource monitoring, reservoir intelligence, and evidence-based planning (Akpoti, 2025; Akpoti et al., 2025; Akpoti et al., 2026);
- the CIS-CSA Visualization Tool, which supports intervention mapping, donor coordination, and spatial planning for climate-smart agriculture implementation (Inusah & Abera, 2024; Visualization Tool for CIS-CSA Interventions in Ghana, n.d.);
- HingaSmart, which supports dissemination of agro-climate advisories and climate-risk information (Mvuyibwami et al., 2023; Mvuyibwami et al., 2024; Mvuyibwami et al., 2025); and
- the Risk Reporting and Emergency Response Management System integrated within AIDH (Wilson et al., 2025).

AIDH plays a particularly important role as an interoperability backbone within Ghana's ecosystem. Through federated data systems, APIs, dashboards, and integrated exchange mechanisms,

the platform supports data harmonization, institutional coordination, extension-service integration, and cross-sector agricultural planning (Wilson et al., 2023; Otieno et al., 2026). AgWise complements this role by providing predictive and AI-enabled agronomic intelligence systems capable of integrating seasonal forecasts, crop models, remote sensing, and adaptive agronomic recommendations (Abera et al., 2025; Ahmed et al., 2025; Leroux et al., 2025).

The IWMI Small Reservoirs Dashboard contributes water-resource intelligence for planners and decision-makers by visualizing waterbody dynamics and reservoir information across Ghana (Akpoti, 2025). Meanwhile, the CIS-CSA Visualization Tool supports national and donor-level coordination through visualization of climate-smart agriculture interventions, improving visibility into implementation gaps and geographic coverage (Inusah & Abera, 2024).

Together, these innovations strengthen Ghana's ability to support evidence-based planning, climate-risk management, extension coordination, emergency preparedness, and climate-smart agricultural governance (Ewell et al., 2025; Otieno et al., 2026). They also highlight the growing need for stronger interoperability, institutional anchoring, harmonized data governance, and coordinated scaling pathways across digital agriculture systems (Restrepo et al., 2023; Otieno et al., 2026).

Extension and Advisory Service Providers

A second major user group consists of extension officers, advisory-service providers, district agricultural officers, climate-service intermediaries, and institutional trainers operating within Ghana's agricultural extension ecosystem (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024). These actors serve as critical intermediaries between upstream climate and agronomic intelligence systems and the farmers who make day-to-day production decisions (Grossi, 2023).

Several CGIAR-supported innovations in Ghana are specifically designed to strengthen frontline advisory delivery and climate-risk communication functions. Innovations supporting this user group include:

- the Climate Risk Management in Agricultural Extension (CRMAE) curriculum (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023);
- HingaSmart agro-climate advisory dissemination systems (Mvuyibwami et al., 2023; Mvuyibwami et al., 2024; Mvuyibwami et al., 2025);
- the Cropping Calendar and Digital Advisory Decision Support Tool (DST) (Wilson et al., 2025; Ofosu-Ampong et al., 2024; Ofosu-Ampong et al., 2025; Cropping Calendar and Digital Advisory Decision Support Tool, n.d.);
- Esoko dissemination systems and call-center advisory infrastructure (Kyeremeh & Koi, 2023a; Kyeremeh & Koi, 2023c; Esoko, n.d.);
- AIDH dashboards and extension coordination systems (Wilson et al., 2023; Wilson et al., 2024; Ghana Agricultural Innovation and Data Hub, n.d.); and
- AgWise advisory and recommendation systems (Abera et al., 2025; Tibebe et al., 2025; Ahmed et al., 2025).

While not yet mainstreamed, the CRMAE curriculum is particularly important because it provides the institutional and human-capacity layer necessary for operationalizing climate-smart digital agriculture systems (List et al., 2023; Trzaska et al., 2023). Through competency-based and participatory training approaches, the curriculum equips extension officers with skills in climate literacy, probabilistic forecasting, climate-risk communication, participatory advisory systems, maproom utilization, and digital climate-service interpretation (Trzaska et al., 2024; Grossi, 2023).

The Cropping Calendar and DST platform supports extension officers through localized crop-management guidance, operational scheduling, planting recommendations, and bundled agro-advisory systems tailored to agroecological conditions in Northern Ghana (Wilson et al., 2025; Ofosu-Ampong et al., 2024). HingaSmart similarly

supports extension systems through dissemination of agro-climate advisories, climate-risk messaging, and forecast-informed recommendations (Mvuyibwami et al., 2024; Mvuyibwami et al., 2025).

Esoko complements these systems by providing dissemination infrastructure through SMS, call centers, mobile communication channels, and farmer-facing advisory systems (Nii-Koi, 2021; Kyeremeh & Koi, 2023a). AIDH dashboards and integrated extension systems additionally support extension coordination, farmer-database management, and geographically tailored advisory dissemination (Wilson et al., 2023; Tepa et al., 2025).

Unlike national technical systems, which focus on analytics and upstream intelligence generation, these innovations emphasize translation, communication, contextualization, and field-level decision support (Grossi, 2023; Trzaska et al., 2024). Together, they support the evolution of Ghana's extension ecosystem toward more climate-smart, digitally enabled, and climate-risk-informed advisory systems (Ewell et al., 2025; Otieno et al., 2026).

Farmers and Producer Organizations

A third major user group consists of smallholder farmers, farmer organizations, producer groups, and irrigation users who interact directly with digital advisory systems designed to support day-to-day livelihood and production decisions (Restrepo et al., 2023; Ewell et al., 2025).

Several CGIAR-supported innovations are specifically designed for farmer-facing use, improving access to climate information services, agronomic recommendations, irrigation planning, and climate-smart advisory services.

These include:

- Esoko dissemination and bundled advisory systems (Nii-Koi, 2021; Kyeremeh & Koi, 2023a; Kyeremeh & Koi, 2023b; Esoko, n.d.);
- HingaSmart agro-climate advisory systems (Mvuyibwami et al., 2023; Mvuyibwami et al., 2024; Mvuyibwami et al., 2025);
- the Cropping Calendar and Digital Advisory Decision Support Tool (DST) (Wilson et al., 2025; Ofosu-Ampong et al., 2024; Ofosu-Ampong et al., 2025; Cropping Calendar and Digital Advisory Decision Support Tool, n.d.)
- AgWise recommendation systems (Abera et al., 2025; Ahmed et al., 2025; Tibebe et al., 2025; AgWise, n.d.); and
- IRRILINE irrigation advisory services (IRRILINE: A new service from Farmerline, n.d.; IRRILINE: A new service from Farmerline YouTube Video, n.d.).

AgWise supports farmers through site-specific fertilizer recommendations, planting-date optimization, cultivar advisory systems, and AI-enabled climate-smart agronomic recommendations (Ahmed et al., 2025; Leroux et al., 2025; Moltote et al., 2025; Tibebe et al., 2025). By integrating climate forecasts, crop models, remote sensing, and soil-health analytics, the platform supports adaptive and precision-oriented decision-making (Abera et al., 2025).

The Cropping Calendar and DST system similarly provides localized crop-management guidance, operational planting schedules, and context-specific agronomic recommendations (Wilson et al., 2025). Behavioral studies and pilot activities demonstrated the importance of participatory design, localized advisory systems, and bundled dissemination approaches for improving adoption among farming communities (Ofosu-Ampong et al., 2024; Ofosu-Ampong et al., 2025).

Esoko and HingaSmart both play important dissemination roles through SMS systems, call centers, localized climate advisories, and digital communication channels that enable farmers to access climate-sensitive advisory information (Nii-Koi, 2021; Kyeremeh & Koi, 2023a; Mvuyibwami et al., 2024). IRRILINE complements these systems by supporting irrigation planning, investment guidance, and water-management decision-making for smallholder irrigation users (IRRILINE: A new service from Farmerline, n.d.).

These innovations depend heavily on upstream climate-information systems, interoperable data infrastructure, and extension dissemination systems (Wilson et al., 2023; Otieno et al., 2026). When harmonized effectively, they can strengthen climate-smart decision-making at scale while supporting Ghana's broader agricultural resilience and climate-adaptation objectives (Ewell et al., 2025; Grossi, 2023).

Researchers, Universities and Training Institutions

A fourth major user group includes universities, agricultural colleges, research institutions, and training organizations involved in curriculum development, climate-services research, extension training, and digital agriculture capacity strengthening (List et al., 2023; Trzaska et al., 2024; Grossi, 2023).

Institutions such as CSIR, universities, extension-training centers, and CGIAR partners increasingly rely on digital agriculture systems for applied research, climate analytics, teaching, extension training, and agricultural data management (Wilson et al., 2023; Abera et al., 2025; Otieno et al., 2026).

Relevant innovations for this group include:

- AgWise climate-intelligence and agronomic modeling systems (Abera et al., 2025; Ahmed et al., 2025; Tibebe et al., 2025);
- AIDH data infrastructure and agricultural datasets (Wilson et al., 2023; Wilson et al., 2024; Ghana Agricultural Innovation and Data Hub, n.d.);
- the CRMAE curriculum and associated training systems (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023);
- the Cropping Calendar and DST platform (Wilson et al., 2025; Ofosu-Ampong et al., 2024; Cropping Calendar and Digital Advisory Decision Support Tool, n.d.);
- HingaSmart advisory systems (Mvuyibwami et al., 2023; Mvuyibwami et al., 2025); and
- the IWMI Small Reservoirs Dashboard (Akpoti et al., 2025; Akpoti et al., 2026).

AgWise is particularly valuable for training and applied research because it integrates machine learning, probabilistic forecasting, crop simulation models, remote sensing, and agronomic intelligence systems within a modular and interoperable architecture (Abera et al., 2025; Tibebe et al., 2025). The platform provides opportunities for teaching climate-smart agronomy, predictive analytics, digital advisory systems, and precision agriculture (Ahmed et al., 2025; Leroux et al., 2025).

The CRMAE curriculum additionally demonstrates how climate-risk management, digital agriculture, climate-information services, and extension-system strengthening can be institutionalized through competency-based curricula and agricultural training systems (Trzaska et al., 2024; Grossi, 2023).

AIDH contributes important infrastructure for research and training through integrated agricultural datasets, dashboards, visualization systems, and interoperable data systems suitable for applied research, student projects, and digital agriculture coursework (Wilson et al., 2023; Tepa et al., 2025; Otieno et al., 2026).

Integrating these systems into formal pre-service and in-service training structures creates important pathways for long-term institutionalization of digital agriculture competencies, climate literacy, and climate-smart advisory capacities within Ghana's agricultural workforce (List et al., 2023; Trzaska et al., 2023; Ewell et al., 2025).

Multisectoral Planners and Humanitarian and Development Partners

A fifth user group includes development partners, NGOs, humanitarian agencies, donor organizations, private-sector service providers, and multi-sectoral planners who rely on digital systems that aggregate, integrate, and synthesize information across climate, agriculture, irrigation, extension, and disaster-risk-management systems (Restrepo et al., 2023; Ewell et al., 2025).

Relevant innovations supporting this user group include:

- the CIS-CSA Visualization Tool (Inusah & Abera, 2024; Visualization Tool for CIS-CSA Interventions in Ghana, n.d.)
- AIDH interoperable dashboards and data systems (Wilson et al., 2023; Wilson et al., 2024; Tepa et al., 2025; Ghana Agricultural Innovation and Data Hub, n.d.);
- the IWMI Small Reservoirs Dashboard (SWaRD) (Akpoti, 2025; Akpoti et al., 2025; Akpoti et al., 2026);
- AgWise climate-intelligence systems (Abera et al., 2025; Tibebe et al., 2025; AgWise, n.d.);
- HingaSmart climate-advisory systems (Mvuyibwami et al., 2023; Mvuyibwami et al., 2024; Mvuyibwami et al., 2025);
- and emergency-response systems integrated within AIDH (Wilson et al., 2025).

These users rely on integrated analytics, spatial planning systems, climate-risk information, intervention mapping, and agricultural intelligence to support coordination, targeting, investment planning, climate adaptation, and resilience-building activities (Otieno et al., 2026; Ewell et al., 2025).

The CIS-CSA Visualization Tool is particularly important because it supports mapping and coordination of climate-smart agriculture interventions across Ghana, improving visibility into implementation activities and reducing duplication among development partners (Inusah & Abera, 2024). SWaRD similarly contributes water-resource intelligence and planning support relevant to irrigation, aquatic food systems, and climate adaptation (Akpoti et al., 2026).

AIDH further strengthens coordination through interoperable data systems, integrated dashboards, and agricultural data-sharing infrastructure capable of supporting multi-stakeholder planning and evidence-based decision-making (Wilson et al., 2023; Otieno et al., 2026).

Together, these user groups illustrate how Ghana's digital agriculture ecosystem increasingly functions as an interconnected—but still partially fragmented—supply chain extending from upstream climate and agricultural intelligence generation to downstream advisory dissemination, extension delivery, institutional learning, and long-term capacity strengthening (Restrepo et al., 2023; Ewell et al., 2025).

Understanding these user clusters is essential for identifying opportunities to harmonize systems, strengthen interoperability, streamline dissemination pathways, reduce duplication, and support long-term institutional uptake of CGIAR-supported innovations (Otieno et al., 2026; List et al., 2023).

The Digital Agriculture Landscape

Ghana's digital agriculture landscape is evolving rapidly as government agencies, CGIAR centers, development partners, research institutions, and private-sector actors increasingly invest in climate-smart digital systems to support agricultural transformation, climate resilience, and evidence-based decision-making (Restrepo et al., 2023; Ewell et al., 2025). The innovations mapped in this InfoNote illustrate a dynamic but still partially fragmented ecosystem characterized by expanding technical capabilities alongside persistent institutional and interoperability challenges (Otieno et al., 2026).

Over the past several years, the demand for localized climate information services, interoperable agricultural data systems, digital extension services, AI-enabled agronomic intelligence, and climate-risk management systems has accelerated in response to increasing climate variability, drought risk, food-security pressures, and the need for adaptive agricultural planning (Restrepo et al., 2023; Grossi, 2023). Innovations such as the Ghana Agricultural Innovation and Data Hub (AIDH), AgWise, HingaSmart, the Cropping Calendar and Digital Advisory Decision Support Tool (DST), the IWMI Small Reservoirs Dashboard (SWaRD), IRRILINE, Esoko, and the CIS-CSA Visualization Tool collectively demonstrate the growing sophistication of Ghana's digital agriculture ecosystem (Wilson et al., 2023; Abera et al., 2025; Mvuyibwami et al., 2025; Wilson et al., 2025; Akpoti et al., 2025; IRRILINE: A new service from Farmerline, n.d.; Kyeremeh & Koi, 2023a; Inusah & Abera, 2024).

These systems support a broad range of functions, including climate-risk management, climate-advisory dissemination, irrigation planning, reservoir intelligence, AI-enabled agronomic recommendation systems, emergency-response coordination, visualization of climate-smart agriculture interventions, extension-service strengthening, and evidence-based agricultural planning (Wilson et al., 2025; Tibebe et al., 2025; Akpoti et al., 2026; Trzaska et al., 2024).

At the same time, the ecosystem remains fragmented in several important ways. Many innovations have emerged through time-bound donor-funded or project-based initiatives without built-in strategies for interoperability, long-term hosting, or institutional integration (Otieno et al., 2026).

As a result:

- Multiple platforms provide overlapping advisory, climate-information, and decision-support functions using different dissemination pathways and technical architectures (Restrepo et al., 2023; Ewell et al., 2025);
- Several innovations operate through separate servers, APIs, dashboards, and cloud infrastructures rather than through harmonized national systems (Wilson et al., 2023; Ghana Agricultural Innovation and Data Hub, n.d.);
- Different tools depend on parallel climate-data ingestion and advisory-generation workflows (Mvuyibwami et al., 2024; Tibebe et al., 2025)
- Farmer-facing dissemination systems often operate independently of national agricultural information systems and extension-service architectures (Kyeremeh & Koi, 2023a; Nii-Koi, 2021);
- Cross-institutional data sharing remains inconsistent across ministries, projects, and implementing agencies (Otieno et al., 2026).

This fragmentation creates operational and governance challenges for national institutions. It complicates data governance, increases duplication, creates parallel advisory systems, raises maintenance costs, and weakens sustainability after project closure (Otieno et al., 2026; List et al., 2023).

The Ghana Agricultural Innovation and Data Hub (AIDH) and related interoperability initiatives increasingly aim to address these challenges by providing a federated and integrated digital backbone through which datasets, dashboards, APIs, advisory systems, and visualization tools can be linked across institutions and sectors (Wilson et al., 2023; Wilson et al., 2024; Tepa et al., 2025; Ghana Agricultural Innovation and Data Hub, n.d.).

At the same time, the Climate Risk Management in Agricultural Extension (CRMAE) initiative demonstrates how extension systems and institutional training architectures can support operational uptake and long-term sustainability (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023).

Despite fragmentation challenges, Ghana's ecosystem presents major opportunities for

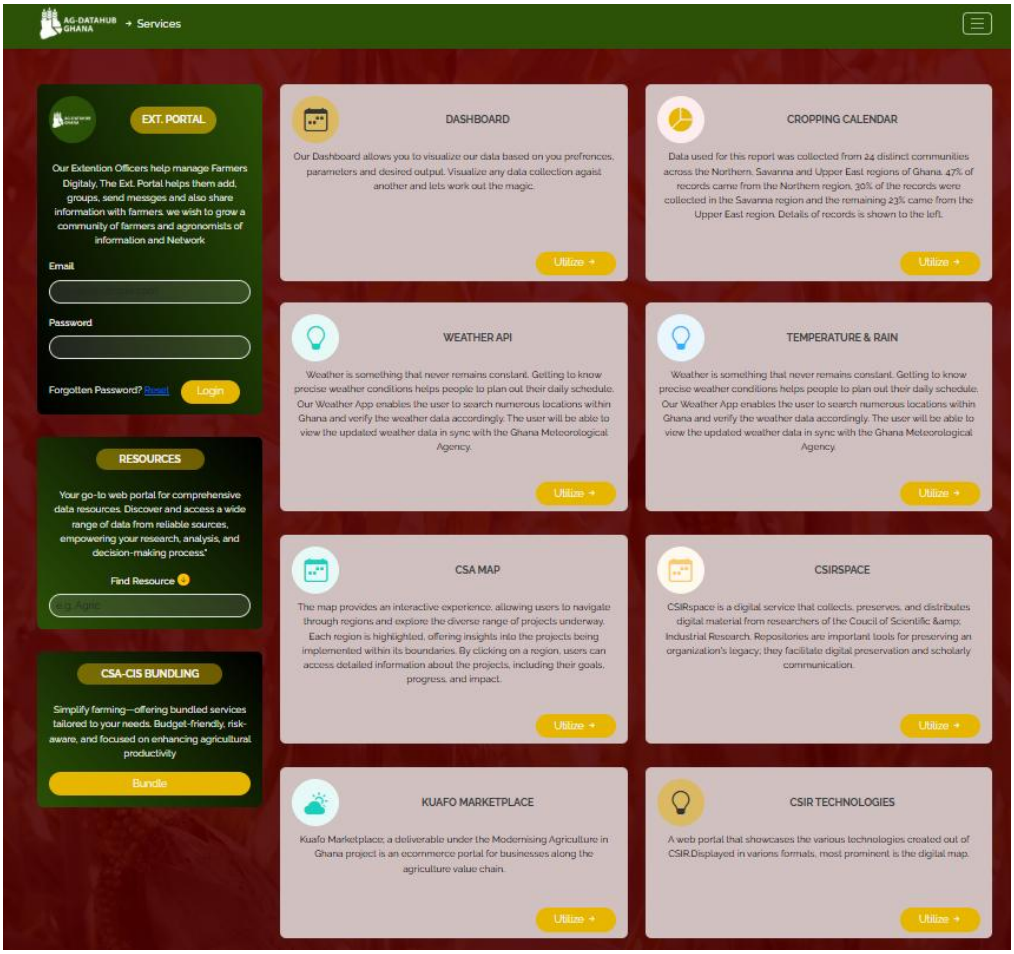


Figure 1: The Ghana Agricultural Innovation and Data Hub (AIDH) integrates multiple digital agriculture services—including climate-information systems, cropping calendars, dashboards, APIs, extension portals, visualization tools, and agricultural resource platforms—within a centralized and interoperable digital ecosystem. The platform functions as a federated hub linking climate-smart agriculture services, advisory systems, data infrastructure, and extension-support tools to strengthen evidence-based planning, climate-risk management, and agricultural service delivery in Ghana.

harmonization and complementarity. AI-enabled agronomic intelligence systems such as AgWise can draw on climate-information services and interoperable datasets from AIDH (Abera et al., 2025; Tibebe et al., 2025). Advisory dissemination systems such as HingaSmart and Esoko can operationalize climate-sensitive recommendations generated through upstream climate and agronomic intelligence systems (Mvuyibwami et al., 2025; Kyeremeh & Koi, 2023a). Water-resource intelligence systems such as SWaRD and irrigation advisory systems such as IRRILINE can complement climate-risk management and agricultural planning functions (Akpoti et al., 2026; IRRILINE: A new service from Farmerline, n.d.). Extension curricula and training systems can institutionalize digital agriculture competencies within extension and advisory systems (Trzaska et al., 2024; Grossi, 2023).

Taken together, the innovations mapped suggest an ecosystem that is rich in technical potential but still requires deliberate harmonization, interoperability governance, institutional anchoring, and coordinated scaling pathways (Otieno et al., 2026; Ewell et al., 2025). With strong leadership from the Ministry of Food and Agriculture (MoFA), Ghana Meteorological Agency (GMet), Council for Scientific and Industrial Research (CSIR), and associated CGIAR and development partners, Ghana has significant opportunities to move toward a more integrated climate-smart agricultural intelligence ecosystem (Wilson et al., 2023; Trzaska et al., 2023; Restrepo et al., 2023).

Complementarity Across Innovations

Despite apparent overlap across several platforms and advisory systems, Ghana's digital agriculture innovations demonstrate strong complementarity when viewed across the broader climate-smart agricultural decision-making spectrum (Restrepo et al., 2023; Ewell et al., 2025).

Upstream innovations—including AgWise climate-intelligence systems, HingaSmart climate-advisory architectures, the IWMI Small Reservoirs Dashboard (SWaRD), and interoperable systems within AIDH—generate climate, agronomic, hydrological, and spatial analytics that support planning, forecasting, climate-risk management, and agricultural intelligence generation (Abera et al., 2025; Tibebe et al., 2025; Mvuyibwami et al., 2024; Akpoti et al., 2026; Wilson et al., 2023).

Intermediate-level innovations—including the Cropping Calendar and Digital Advisory Decision Support Tool (DST), HingaSmart dissemination systems, and AIDH dashboards—translate climate and agronomic intelligence into actionable advisory recommendations tailored to local farming systems and agroecological conditions (Wilson et al., 2025; Ofosu-Ampong et al., 2024; Mvuyibwami et al., 2025; Tepa et al., 2025).

Downstream dissemination systems—including Esoko advisory systems, SMS dissemination channels, call-center services, and extension delivery systems—support communication of climate-smart advisories and farmer-facing recommendations (Nii-Koi, 2021; Kyeremeh & Koi, 2023a; Kyeremeh & Koi, 2023c). Their effectiveness depends heavily on harmonized upstream data systems and coordinated advisory pipelines to avoid contradictory or fragmented messaging (Otieno et al., 2026).

Cross-cutting integrators such as AIDH play a particularly important role by supporting interoperability, agricultural data exchange, visualization systems, and integrated dashboards capable of linking climate services, agronomic intelligence, extension systems, and agricultural governance platforms (Wilson et al., 2023; Wilson et al., 2024; Ghana Agricultural Innovation and Data Hub, n.d.).

Meanwhile, the CRMAE curriculum provides the institutional and human-capacity layer necessary for operationalizing climate-smart digital agriculture systems through extension systems, advisory-service providers, agricultural colleges, and training institutions (List et al., 2023; Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023).

Together, these innovations form a potentially mutually reinforcing ecosystem—provided their hosting arrangements, dissemination pathways, climate-information systems, APIs, dashboards, and advisory architectures are deliberately harmonized (Otieno et al., 2026; Ewell et al., 2025).

Mainstreaming and Scaling Pathways

Ensuring the long-term sustainability, coherence, and government integration of digital agriculture innovations requires deliberate institutional anchoring across Ghana's public sector, research institutions, extension systems, and digital governance architectures (Otieno et al., 2026; Ewell et al., 2025). While the Ministry of Food and Agriculture (MoFA), Ghana Meteorological Agency (GMet), Council for Scientific and Industrial Research (CSIR), International Water Management Institute (IWMI), and associated CGIAR partners already play important implementation and coordination roles, agricultural colleges, universities, and extension-training systems also represent critical—but often underrecognized—pathways for long-term national uptake and institutionalization (Trzaska et al., 2024; Grossi, 2023).

Ministry of Food and Agriculture (MoFA)

The Ministry of Food and Agriculture (MoFA) is the natural institutional anchor for farmer-facing advisory systems, digital extension architectures, crop-management tools, and climate-smart dissemination systems (Restrepo et al., 2023). Innovations such as HingaSmart, the Cropping Calendar and Digital Advisory Decision Support Tool

(DST), Esoko dissemination systems, and AIDH extension dashboards become significantly more sustainable when integrated into MoFA's district-level advisory structures, extension-service workflows, and agricultural planning systems (Mvuyibwami et al., 2025; Wilson et al., 2025; Kyeremeh & Koi, 2023a; Wilson et al., 2023).

MoFA additionally plays a critical bridging role between digital agriculture innovations and extension-training systems by supporting integration of climate-smart advisory tools, climate-information services, and digital agriculture competencies into extension-service delivery and agricultural training curricula (Trzaska et al., 2024; Grossi, 2023).

Ghana Meteorological Agency (GMet)

The Ghana Meteorological Agency (GMet) remains the authoritative source of climate information, seasonal forecasting, and national climate-service coordination in Ghana. As such, climate-information systems, agro-climate advisories, probabilistic forecasting systems, and forecast-based agricultural decision-support tools should remain closely linked to GMet to ensure consistency, scientific credibility, and long-term operational sustainability (Mvuyibwami et al., 2024; Tibebe et al., 2025).

GMet's stewardship role is particularly important for climate-information dissemination systems integrated into HingaSmart, AgWise, the CRMAE curriculum, and associated climate-risk-management architectures (Trzaska et al., 2024; Ahmed et al., 2025).

Council for Scientific and Industrial Research (CSIR)

The Council for Scientific and Industrial Research (CSIR) plays an important role in agricultural innovation, climate-smart agriculture research, extension-system strengthening, agricultural data management, and digital advisory-system development in Ghana (Wilson et al., 2023; Abera et al., 2025). CSIR has already contributed significantly to implementation and scaling activities associated with AIDH, Esoko dissemination systems, HingaSmart, and extension-capacity-development initiatives (Kyeremeh & Koi, 2023c; Wilson et al., 2024).

CSIR is therefore well positioned to support long-term technical stewardship, interoperability governance, agricultural data management, and scaling pathways for CGIAR-supported digital agriculture systems (Otieno et al., 2026).

International Water Management Institute

The International Water Management Institute (IWMI) plays a critical role in irrigation intelligence, water-resource analytics, reservoir monitoring, and climate-adaptation planning through innovations such as the IWMI Small Reservoirs Dashboard (SWaRD) and IRRILINE (Akpoti et al., 2025; IRRILINE: A new service from Farmerline, n.d.). These systems align closely with Ghana's priorities related to irrigation modernization, climate adaptation, water-resource governance, and aquatic-food-system resilience (Akpoti et al., 2026).

Long-term sustainability of these systems depends on stronger integration with national irrigation planning systems, water-resource governance institutions, extension architectures, and climate-risk-management systems (Akpoti et al., 2025).

Universities, Agricultural Colleges, and Extension Training Systems

A sustainable digital agriculture ecosystem in Ghana depends not only on government ministries and technical agencies but also on universities, agricultural colleges, extension-training institutions, and advisory-service systems responsible for long-term human-capacity development and institutionalization (List et al., 2023; Grossi, 2023).

The Climate Risk Management in Agricultural Extension (CRMAE) initiative demonstrates how climate-smart digital agriculture systems can be mainstreamed into extension curricula, agricultural

colleges, and training architectures through competency-based and participatory learning systems (Trzaska et al., 2023; Trzaska et al., 2024). The curriculum equips extension officers and agricultural professionals with competencies in climate literacy, climate-risk communication, probabilistic forecasting, climate-information interpretation, participatory advisory systems, and digital agriculture tools (Grossi, 2023).

Integrating systems such as AgWise, AIDH dashboards, HingaSmart, climate-information services, and visualization platforms into formal pre-service and in-service training systems creates important pathways for long-term institutionalization of climate-smart digital agriculture competencies within Ghana's agricultural workforce (Abera et al., 2025; Wilson et al., 2023).

The Importance of Interoperability Governance

While Ghana's digital agriculture ecosystem contains significant technical innovation, long-term sustainability depends on coordinated interoperability governance, harmonized data standards, integrated hosting arrangements, and deliberate institutional coordination (Otieno et al., 2026). AIDH increasingly provides an important foundation for this interoperability architecture through federated data systems, integrated dashboards, APIs, and agricultural data-sharing infrastructure capable of linking climate-information systems, advisory architectures, visualization systems, and extension-service platforms (Wilson et al., 2023; Tepa et al., 2025; Ghana Agricultural Innovation and Data Hub, n.d.).

Without stronger interoperability governance, many innovations risk remaining fragmented, project-dependent, and difficult to sustain after donor-funded implementation periods conclude (Ewell et al., 2025; Restrepo et al., 2023).

The Critical Role of Ghana's Education System

A sustainable digital agriculture ecosystem in Ghana depends not only on government ministries and technical agencies but also on universities, agricultural colleges, extension-training institutions, and advisory-service systems responsible for long-term capacity development, institutionalization, and knowledge retention (List et al., 2023; Trzaska et al., 2024). Evidence from the Climate Risk Management in Agricultural Extension (CRMAE) mainstreaming process demonstrates that higher education institutions, extension-training systems, and agricultural colleges are indispensable for sustaining climate-smart agriculture and climate-information-service competencies beyond project implementation cycles (Grossi, 2023; Trzaska et al., 2023).

Ghana's universities, agricultural colleges, extension-training centers, and technical institutions collectively train future extension officers, agricultural technicians, climate-service intermediaries, planners, and agricultural professionals who will increasingly operate within digitally enabled and climate-informed agricultural systems (List et al., 2023). However, many existing agricultural training curricula still contain gaps in climate literacy, climate-information services, digital agriculture competencies, probabilistic forecasting interpretation, and climate-risk communication skills necessary for modern climate-smart agricultural extension systems (Trzaska et al., 2024; Grossi, 2023).

These gaps represent an important constraint to effective uptake and operationalization of emerging digital agriculture innovations such as AgWise, HingaSmart, AIDH, the Cropping Calendar and Digital Advisory Decision Support Tool (DST), Esoko dissemination systems, and climate-advisory platforms (Abera et al., 2025; Mvuyibwami et al., 2025; Wilson et al., 2023; Wilson et al., 2025; Kyeremeh & Koi, 2023a). Even where sophisticated digital systems and climate-information services exist, extension officers and advisory-service providers require sufficient technical capacity to interpret forecasts, communicate climate-risk information, contextualize advisory recommendations, and support farmer decision-making (Trzaska et al., 2024).

The CRMAE initiative therefore represents a particularly important institutional innovation because it demonstrates how climate-smart

agriculture, climate-risk management, climate-information services, and digital advisory systems can be integrated into competency-based and participatory extension-training systems (Trzaska et al., 2023; Trzaska et al., 2024). Through training-of-trainers workshops, consultative curriculum-development processes, and institutional partnerships, the initiative provides pathways for mainstreaming digital agriculture competencies into both pre-service and in-service agricultural training systems (List et al., 2023; Grossi, 2023).

Long-term sustainability of Ghana's digital agriculture ecosystem will therefore depend not only on technical interoperability and digital infrastructure, but also on sustained investment in climate literacy, extension-system strengthening, digital advisory competencies, and institutionalized training systems capable of supporting the next generation of climate-smart agricultural professionals (Ewell et al., 2025; Otieno et al., 2026).

Alignment with National Policies and Strategies

Ghana's CGIAR-supported digital agriculture innovations strongly support implementation of the country's broader national priorities related to climate resilience, agricultural modernization, digital transformation, climate-smart agriculture, and evidence-based planning (Ewell et al., 2025; Restrepo et al., 2023). Increasing climate variability, drought risk, food-security pressures, and the need for adaptive agricultural planning have accelerated demand for localized climate information services, interoperable agricultural data systems, digital extension services, and climate-risk-management frameworks (Ghosh et al., 2025).

Several innovations mapped in this InfoNote—including the Ghana Agricultural Innovation and Data Hub (AIDH), AgWise, HingaSmart, Esoko dissemination systems, the Cropping Calendar and Digital Advisory Decision Support Tool (DST), SWaRD, and IRRILINE—provide operational mechanisms through which Ghana can implement priorities embedded within the Food and Agriculture Sector Development Policy II (FASDEP II), the Medium-Term Agriculture Sector Investment Plan (METASIP), the National Climate Change Policy (NCCP), and broader climate-smart agriculture and agricultural modernization strategies (Wilson et al., 2023; Abera et al., 2025; Mvuyibwami et al., 2025; Wilson et al., 2025; Akpoti et al., 2026).

These systems contribute directly to national priorities related to:

- modernization of agricultural extension systems;
- climate-risk management and climate adaptation;
- irrigation modernization and water-resource management;
- evidence-based agricultural planning;
- digital agriculture and climate-information services;
- agricultural data governance;
- and resilience-building among farming communities (Ewell et al., 2025; Ghosh et al., 2025).

The innovations additionally align strongly with Ghana's broader digital transformation agenda, which emphasizes interoperable digital public infrastructure, integrated government information systems, digital service delivery, and data-driven governance across sectors. In this context, AIDH increasingly functions as a foundational interoperability architecture capable of supporting federated agricultural data exchange, integrated dashboards, APIs, visualization systems, and cross-sectoral planning systems (Wilson et al., 2023; Tepa et al., 2025; Otieno et al., 2026).

Ghana's National Framework for Climate Services (NFCS), launched in 2023 under the leadership of the Ghana Meteorological Agency (GMet), further provides an important institutional framework for coordination of climate-information services across agriculture, water resources, disaster-risk management, and related sectors (Ghosh et al., 2025). The NFCS emphasizes institutional coordination, climate-service delivery, interoperability, climate-risk management, and operational uptake of climate information systems across sectors (Ghosh et al., 2025). Innovations such as AgWise, HingaSmart, Esoko, and the Cropping Calendar and DST operationalize many of these objectives by translating climate science into actionable climate-smart advisories and farmer-

facing decision-support systems (Ahmed et al., 2025; Mvuyibwami et al., 2024; Kyeremeh & Koi, 2023a; Wilson et al., 2025).

The Climate Risk Management in Agricultural Extension (CRMAE) initiative also supports implementation of national adaptation and extension-system-strengthening priorities by institutionalizing climate-risk management, climate-information services, and digital agriculture competencies within agricultural training systems and extension curricula (Trzaska et al., 2023; Trzaska et al., 2024; Grossi, 2023). Through competency-based and participatory training approaches, the initiative strengthens climate literacy, climate-risk communication, probabilistic forecasting interpretation, and digital advisory-system uptake among extension officers and agricultural professionals (List et al., 2023).

Water-resource and irrigation innovations similarly contribute to Ghana's climate adaptation and resilience priorities. The IWMI Small Reservoirs Dashboard (SWaRD) supports reservoir intelligence, irrigation planning, and aquatic-food-system resilience through improved water-resource analytics and evidence-based planning systems (Akpoti et al., 2025; Akpoti et al., 2026). IRRILINE further supports farmer-led irrigation development and climate adaptation among smallholder irrigation users through irrigation-investment guidance and irrigation advisory services (IRRILINE: A new service from Farmerline, n.d.).

Together, these innovations demonstrate that Ghana's digital agriculture ecosystem is increasingly evolving beyond isolated project-based tools toward a broader climate-smart agricultural intelligence ecosystem capable of supporting national adaptation planning, agricultural modernization, digital governance, extension-service strengthening, and climate-resilient agricultural transformation (Otieno et al., 2026; Ghosh et al., 2025). Continued progress, however, will depend on stronger interoperability governance, institutional anchoring, coordinated scaling pathways, and long-term investment in integrated digital public infrastructure for agriculture.

Toward an Integrated Climate-Smart Digital Agriculture Ecosystem in Ghana

Ghana's digital agriculture ecosystem is rapidly evolving from a collection of individual innovations toward a broader climate-smart agricultural intelligence ecosystem capable of supporting climate adaptation, evidence-based planning, digital extension, irrigation management, and resilient agricultural transformation (Otieno et al., 2026; Ewell et al., 2025). The innovations mapped in this InfoNote demonstrate substantial technical sophistication and institutional momentum across climate-information services, agronomic intelligence, interoperability architectures, advisory systems, and climate-risk-management platforms.

At the same time, long-term sustainability will depend less on creation of additional standalone platforms and more on strengthening interoperability, institutional coordination, harmonized data governance, and integrated scaling pathways across existing systems (Restrepo et al., 2023; Ghosh et al., 2025). Platforms such as the Ghana Agricultural Innovation and Data Hub (AIDH) increasingly provide a foundation for interoperable digital public infrastructure capable of linking climate services, agronomic intelligence, extension systems, visualization platforms, and agricultural governance systems through federated data architectures and integrated dashboards (Wilson et al., 2023; Tepa et al., 2025).

Human-capacity development will be equally important. The Climate Risk Management in Agricultural Extension (CRMAE) initiative demonstrates that climate-smart digital agriculture transformation depends not only on technology systems, but also on extension officers, universities, agricultural colleges, and institutional training systems capable of operationalizing climate information and digital advisory services within day-to-day agricultural decision-making processes (Trzaska et al., 2024; Grossi, 2023).

With continued leadership from the Ministry of Food and Agriculture (MoFA), Ghana Meteorological Agency (GMet), Council for Scientific and Industrial Research (CSIR), CGIAR centers, universities,

private-sector actors, and development partners, Ghana is well positioned to become a regional leader in interoperable climate-smart digital agriculture systems. Achieving this vision will require sustained investment in interoperability governance, institutional mainstreaming, digital public infrastructure, extension-system strengthening, and coordinated climate-service delivery capable of supporting long-term agricultural resilience and climate adaptation.

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