# Accelerating inclusive green growth through agri-based innovation in Western Africa (AGriDI)'

## Baseline study of the project in target countries

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LIST OF ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| ACMA | : | Communal Approach to Agricultural Market |
| AGORA | : | Global Online Research in Agriculture |
| AGrIDI | : | Accelerating inclusive Green growth through agri-based Innovation in Western Africa |
| AgrIDS | : | Agricultural Information Dissemination System |
| AI | : | Artificial Intelligence |
| ANAPI | : | National Agency of Industrial Property (Benin?) |
| ARIPO | : | African Regional Intellectual Property Organization |
| ATDA | : | Agence Territoriale de Développement Agricole |
| CTA | : | Technical Centre for Agricultural and Rural Cooperation |
| DOAJ | : | Directory of Open Access Journals |
| ECOWAS | : | Economic Community of West African States |
| FAO | : | Food and Agriculture Organization |
| GIS | : | Geographic Information System |
| GESS | : | Growth Enhancement Support Scheme |
| GSMA | : | Global System for Mobile Communications |
| ICT | : | Information and Communication Technology |
| ICT4AD | : | ICT for Accelerated Development |
| Icipe | : | International Centre of Insect Physiology and Ecology |
| IoT | : | Internet of Things |
| ITU | : | International Telecommunication Union |
| IPR | : | Intellectual Property Right |
| MAEP | : | Ministère de l'Agriculture de l'Elevage et de la Pêche |
| MCI | : | Mobile Connectivity Index |
| NITDA | : | National Information Technology Development Agency |
| OECD | : | Organization for Economic Cooperation and Development |
| PRISMA | : | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |
| UAC | : | University of Abomey-Calavi |
| UAV | : | Unmanned Aerial Vehicle |
| WAAPP | : | West Africa Agricultural Productivity Program |
| WIPO | : | World Intellectual Property Organization |
| WSN | : | Wireless Sensor Network |

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In West Africa, agriculture is a key driver of national economic growth. It ensures food and nutrition security and livelihoods for a large part of the population in this region. However, the global food crisis has disrupted the agri-food systems challenging the ability of countries in this region to cope with the situation and feed their ever-growing population. Hence, deploying digital technologies in agriculture can be one of the solutions to improve the productivity and profitability of small-scale agriculture prevailing in this region.

In this context, the project ''Accelerating Inclusive Green Growth through Agri-based Digital Innovation in West Africa (AGriDI)'' was initiated to promote a conducive environment for agri-based digital innovations, especially for women and youth farmers, and to accelerate inclusive green growth in these targeted countries of West Africa. We carried out a baseline study in five target countries, namely Benin, Burkina-Faso, Cote d'Ivoire, Ghana and Nigeria, to complete the logical framework of the AGriDI project. For this purpose, 3,249 publications, including articles, reviews, chapters and proceedings, were retrieved and subjected to a bibliometric analysis, which revealed that research on innovations in agriculture in this region started in 1975 and has gained interest considerably since 2014. The bulk of the publications in digital agriculture come from Nigeria, followed by Ghana, Benin, Burkina and Côte d'Ivoire. In general, machine learning, sensor networks and artificial intelligence were the most explored digital agriculture technologies, and ''impact of systems'', ''agriculture'' and ''adoption'' were some of the hot topics in West Africa. On the other hand, the assessment of use cases and deployment of digital technologies in these countries through a systematic review approach revealed that the Internet of Things (IoT), Wireless Sensors Networks, Artificial Intelligence, Block chain, Unmanned Aerial Vehicle (UAV), Big data, and Geographic Information Systems (GIS) are the leading digital agriculture technologies used in the five AGriDI countries.

The results also indicated a variety of innovations, including E-agriculture platforms and E-startups, existing among the five countries, which help farmers access agricultural inputs and markets for their products and connect the consumers to farms. Meanwhile, the rate of development of these digital innovations in agriculture was closely linked to the efforts of each country to provide the enabling policies and strategies to guarantee access to basic connectivity infrastructure (electricity and Internet). For example, the Mobile Connectivity Index (MCI) in the five countries is still below 60, with the highest values recorded in Ghana and Nigeria, which promote more innovations in their country than in others. Interestingly, all five countries have acknowledged the need to embrace a digital economy and developed either a separate

document outlining their strategic Digital Agriculture plan (Benin and Nigeria) or embedded it in their national development plans (Ghana and Côte d'Ivoire). The five countries have also recognized the importance of Intellectual Property Rights (IPRs) to accelerate innovations and have passed and/or enacted various acts and agreements at different levels which provide the developers access to multiple platforms to the applicants to protect their inventions. Based on the literature, baseline indexes were also set to monitor the project's impact.

To address barriers to digital agriculture innovation, these countries must reposition themselves to accelerate the development of digital agriculture through a continuous effort towards i) creating the enabling environment, ii) developing the enabling infrastructures: iii) accelerating Research and Innovations and iv) Promoting IPRs as interconnected parts of a practical road map for achieving the paradigm shift for boosting the agri-food systems in these countries and West Africa at large. Recommendations were also made to help the AGriDI projects successfully contribute to agri-digital transformation of the countries.

## 1. General context

Agriculture plays a vital role in feeding people, animals, and businesses in interconnected economies worldwide. According to the World Bank (2022), the development of agriculture can help reduce poverty, raise incomes and improve food security for 80% of the world's poor, who live in rural areas and work mainly in farming. Agriculture contributes to poverty reduction by acting as an economic engine in developing countries (Figure 1).

However, the global food crisis due to climate change and the recent COVID-19 pandemic has caused significant disruptions in agri-food systems worldwide, particularly in sub-Saharan countries, challenging each country's ability to cope with the crisis. The growing population of these countries must be fed while adapting to an increasingly devastating context: climate change, the collapse of biodiversity, and the reduction of resources. Therefore, strategies and innovations are needed to support agri-food systems and increase their resilience.

The digitalization of agriculture has emerged as a solution to revolutionize small-scale agriculture in developing countries by significantly improving productivity and profitability (CTA, 2018). E-agriculture has a solid potential to boost financial development and increase the incomes of the rural poor by improving their skills, increasing employment, and improving the value chain.

In Africa, digital agriculture is gradually taking off but barely reaching 6% of its potential (CTA, 2018; FAO & ITU, 2022). According to CTA, agricultural innovations are linked to three drivers: autonomous agrarian vehicles, big data, and new, more responsible, and sustainable consumption channels (CTA, 2018). Adopting e-technology in agriculture is a crucial driver for decent livelihoods, income generation, poverty reduction, nutrition and security (Eweoya et al., 2021b). Nigeria accounts for more than half of the population and more than 65% of West African agricultural production in West Africa, followed by Ghana and Côte d'Ivoire. These three countries have diversified economies linked to oil wealth or industrial dynamics. In Burkina Faso and Benin, the agricultural sector contributes to about 20 % and 30 % of the GDP, respectively (Figure 1). It is, therefore, undeniable that the digital revolution in these countries can improve their agricultural productivity and economic growth.

Recently, a consortium made of the International Centre of Insect Physiology and Ecology (icipe), the Agropolis Foundation (AF), Gearbox Pan African Network (GB), and the Université d'Abomey-Calavi (UAC), Benin was awarded a project funded by EU and titled ''Accelerating Inclusive Green Growth through Agri-based Digital Innovation in West Africa (AGriDI)'' to promote a conducive environment for agri-based digital innovations, especially for women and youth farmers, and to accelerate inclusive green growth in these targeted countries of West Africa.

To complete the logical framework of the project, there was a need to conduct a baseline study to assess the state of agri-digital technologies in the target 5 countries

resulting from the selected sub-projects as part of the AGriDI implementation. This study also aims at surveying the related challenges, including the issue of intellectual property rights in Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Nigeria. Primarily, the mission aimed to i) undertake a comprehensive scoping of the state/status (innovations/technologies, actors, relations, institutional factors) of the agri-based digital innovations/technologies in the five countries of AGriDI, ii) make an inventory and describe the agri-based innovations/technologies (e-agriculture) and, iii) assess the status of the IPR in the 5 countries.

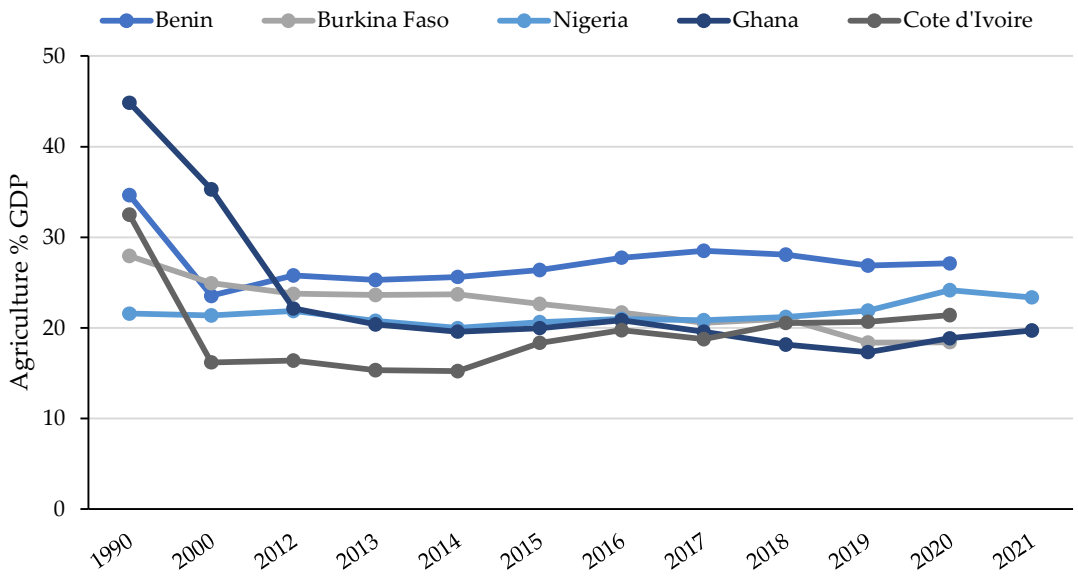



**Figure 1.** Added value[1] of the agricultural sector to the country GDP over the years

[1] https://databank.worldbank.org/reports.aspx?source=2&series=NV.AGR.TOTL.ZS&country=#

## 2. Methodology

To contribute to digital inclusion in agriculture in the AGriDI target countries (Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Nigeria), we assessed the current state of Innovation in each of these countries. We adopted a mixed methodological approach (Figure 2).

The primary objective of this study is to assess the status of countries and knowledge of digital agriculture research in West Africa. This type of analysis can be carried out through a systematic analytical technique that identifies the most influential researchers, their affiliations, the keywords they choose and, most importantly, how academic work relates to each other. The bibliometric approach is appropriate for assessing the current status of a particular discipline using different indicators, such as highly cited publications, researchers, journals, academic institutions, and countries.

First, we reviewed the related work on review studies on digital agriculture. Second, through a quantitative approach based on bibliometric data analysis, we identified key research, authors, and their relationship, covering all publications related to a given topic or field. All scientific contributions to digital agriculture in West Africa were reviewed using this search string. The bibliometric search was performed on the Web of Science, and the bibliometric database was exported on 28 September 2022. The search string is: *(Agriculture OR Agricultural OR" Food production"OR "Farming system" OR Farming) AND (Innovation OR Numeric OR Digital OR Smart OR Automatic OR "Artificial intelligence" OR "Internet of things" OR "Machine learning" OR "Automated learning" OR Blockchain OR "Big data" OR "Data science" OR "Wireless technologies" OR "Mobile network" OR "Sensor network") AND (Benin OR Nigeria OR "Ivory Coast" OR "Cote d'Ivoire" OR Ghana OR "Burkina Faso" OR "West Africa")*. Using the above search string, 3249 publications were retrieved from the Web of Science, including articles, reviews, chapters, and proceedings. The records were exported in BibTeX and txt files, including authors, publication year, title, abstract, subject categories, source journal, and references. The data were analyzed using biblio-shiny, Bibliometric, and VOSviewer software. Third, we assessed the use cases and deployment of digital technologies in the countries through a systematic review approach based on a comparative analysis of technologies used in the target countries; papers have been selected based on the previous bibliometric study and other sources. At this stage, we relied on the content of the most cited articles and publications from the cases of the different organizations in the different countries, but also and above all, on papers presenting tangible cases of deployment in the target countries from sources, such as Web of science, Scopus, Science Direct, Google Scholar, IEEE, MDPI and the web pages of the digital ministries of the countries AGriDI, AGORA and DOAJ. Published papers during the last 5 years were selected from the bibliometric study to perform a comparative analysis of technologies used in the target countries. In total, 468 scientific documents were retrieved. First, filtering was performed to exclude articles based on title, the origin of the study, and whether the innovation/technology is used in agriculture. A second filtering was performed by reading the abstracts, keywords, and conclusions. After sorting, thirty papers dealing with practical cases of digital farming deployment in the five countries concerned allowed us to present the actual state of evolution of the countries with regard to digital farming. Based on this literature review, the primary lines of innovations and technologies were shown as West African countries' context and level of advancement.

For each document, we retrieved information about the innovations/technologies used, the actors who used them, the use cases, the institutional factors, the issues related to their

use, the year of creation of the Innovation, the year of the study, the country of invention, the status of IPRs.

Based on this literature review, the primary lines of innovations and technologies were presented, as well as each country's context and level of advancement. Finally, given the valuable nature of performance indicators in this results-oriented project, special attention is given to defining the baseline values of the different indicators in the logical framework.

It is worth noting that the terms ''digital agriculture'' and ''e-agriculture'' were used interchangeably in the report.

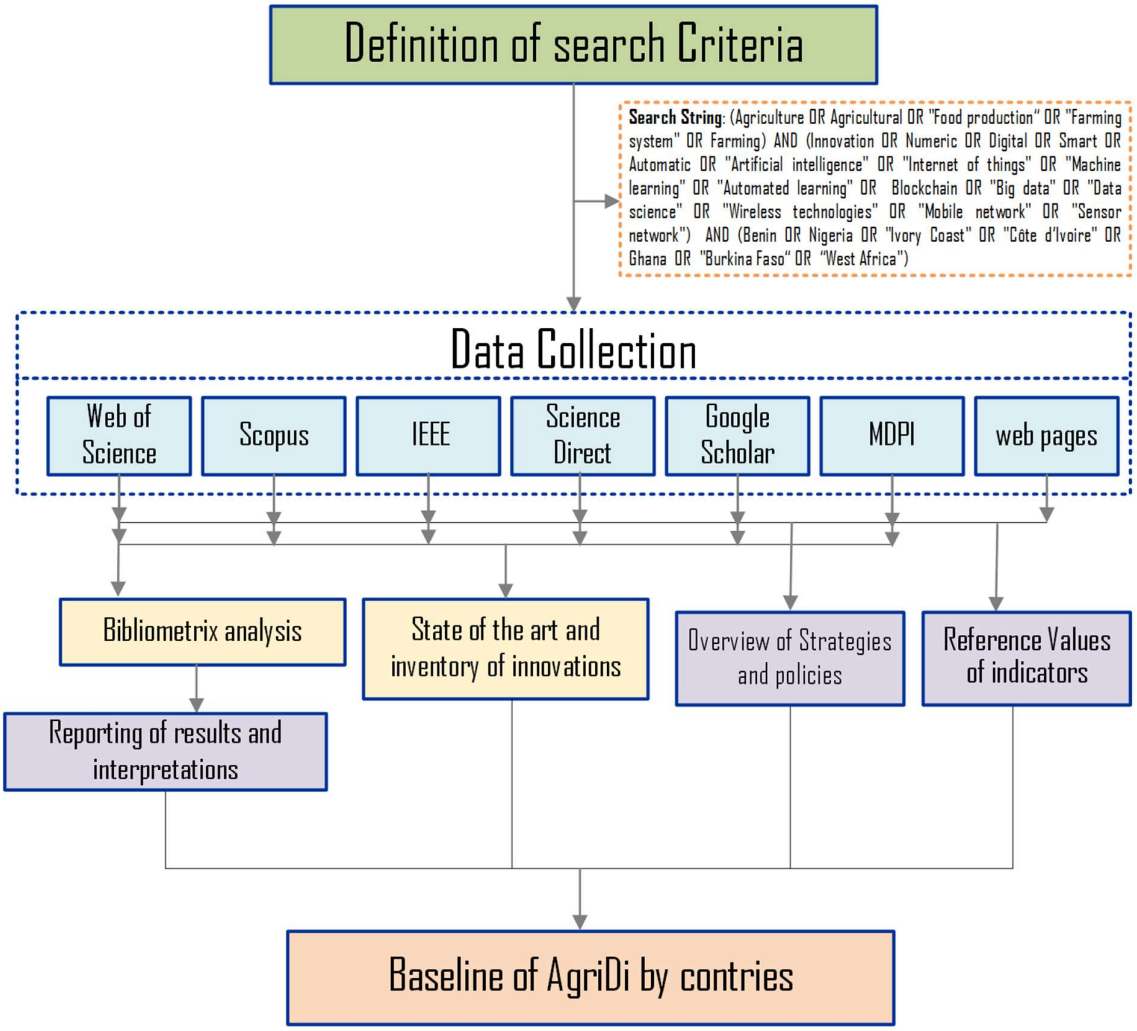



**Figure 2.** Methodological Approach used in the study

## 3. Environment of Digital Agriculture technology/innovation development in the AGriDi target countries

### 3.1. Bibliometric review

Bibliometric analysis is a computer-assisted scientific review methodology that allows the identification of key research or authors and their relationship, covering all publications related to a given topic or field. In this section, we reported the results of the bibliometric study of research on digital agriculture. We assessed the contributions of researchers, institutions, and target countries of the AGriDI project. For this purpose, 3,249 publications were retrieved from the Web of Science, including articles, reviews, chapters and proceedings using the string of research presented above.

❖ **Annual Scientific Production**

Figure 3 shows the number of publications on digital farming since 1975. It is easy to see that research interest in digital agriculture is not new. Since 1975, research work has focused on Innovation in agriculture. However, since 2014, the research interest has increased considerably with publications. In 2021, more than 550 publications were indexed in the Web of science.

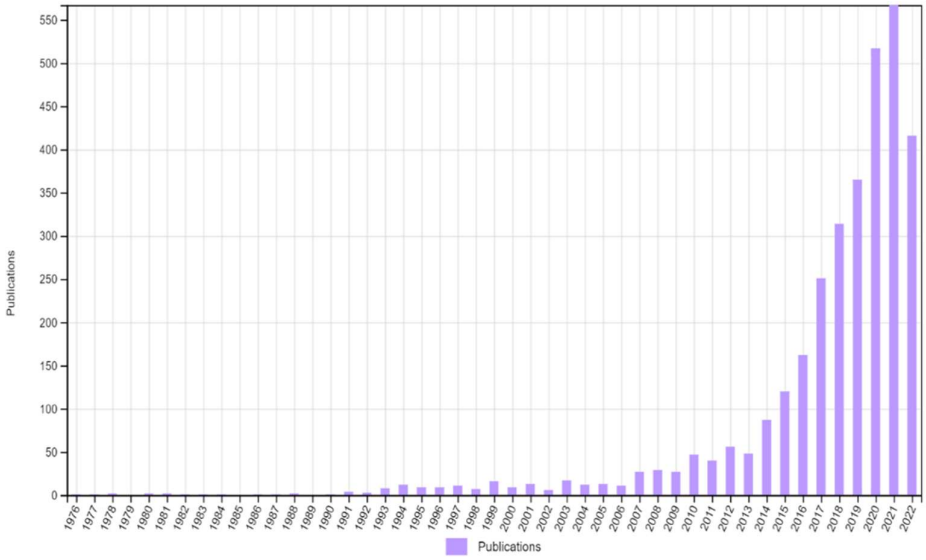



**Figure 3.** Histogram of publications per year

## ❖ Relevant Source

Figure 4 shows the top 20 most relevant sources of collected data. The African Journal of Science Technology Innovation ranks first with 83 documents published on the subject, then Discovery and Innovation with 82 documents, and Innovation and Technologies for Sustainable Agriculture with 62 documents.

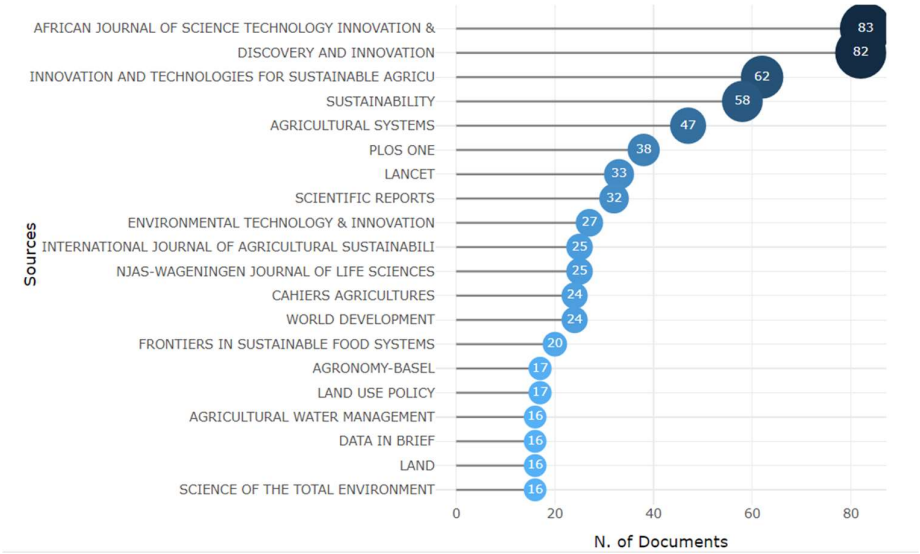



**Figure 4.** Top 20 most relevant Source

## ❖ Author Countries

Figure 4 presents the scientific contributions to innovation in digital agriculture according to the authors' countries of origin. In the five countries, the bulk of the publications in digital agriculture were obtained from Nigeria (the most populous of the five target countries), followed by Ghana. On the other hand, the English-speaking countries (Ghana and Nigeria) contributed more to advancing knowledge in digital agriculture than the francophone countries in the following order: Benin, Burkina, and Côte d'Ivoire. There is also a strong collaboration between these countries and the rest of the world in these publications, including collaboration with other countries, such as England, USA, South Africa, Germany0, and China. Although this may call for increased scientific partnership, it should be noted that only English-language publications were considered for this study.

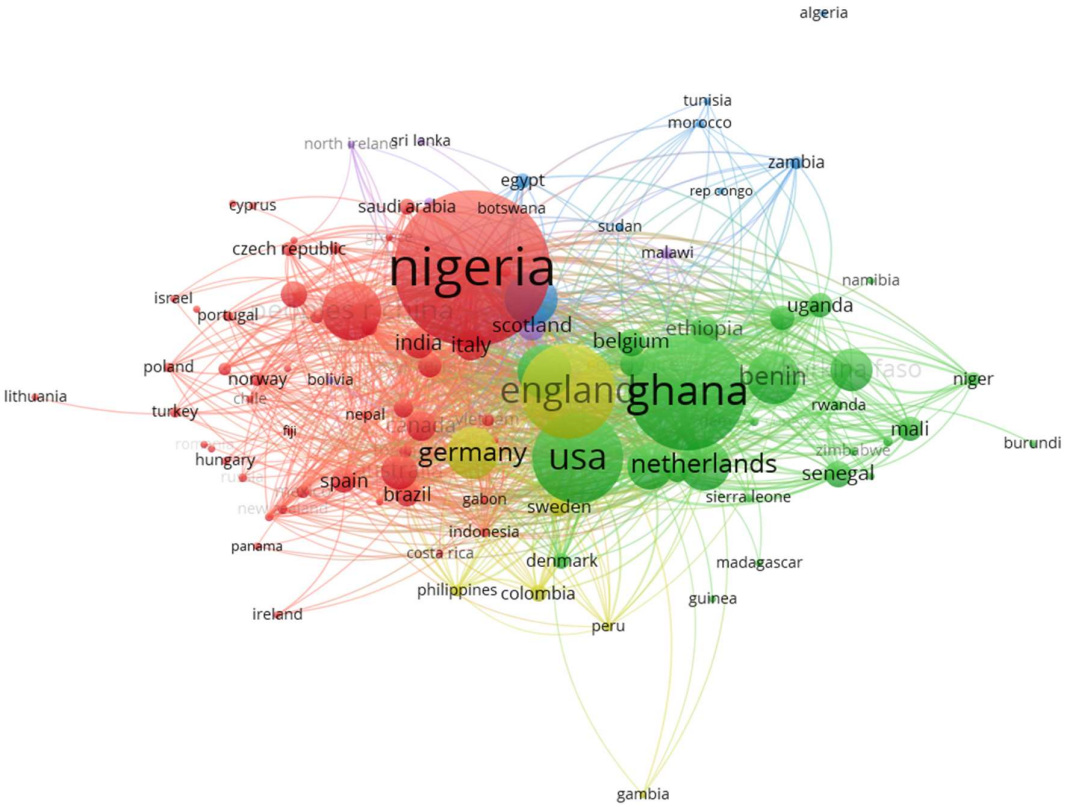



**Figure 5.** Map of author Countries

## ❖ Author Organizations

Most of the publication sources were obtained from academia. The university of Ghana recorded the highest number of publications, followed by Nigerian universities (university of Nigeria, Opkara Agro university, university of Ibadan) and the university of Abomey-Calavi. Other sources include research institutions and international organizations.

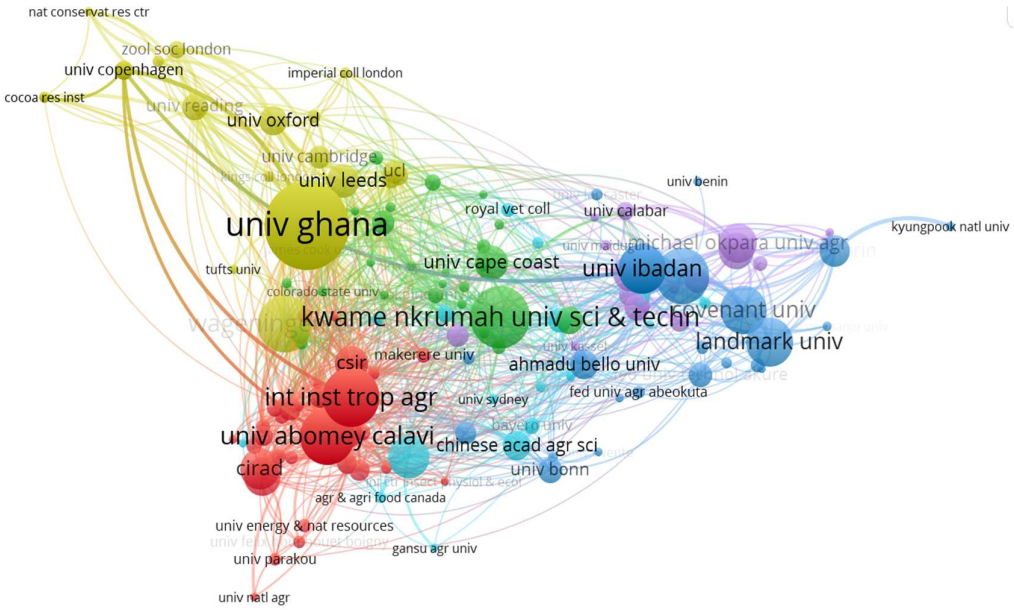



*Figure 6. Map of author Organizations*

## ❖ Most Global cited Documents

The best papers cited overall are presented in the figure.

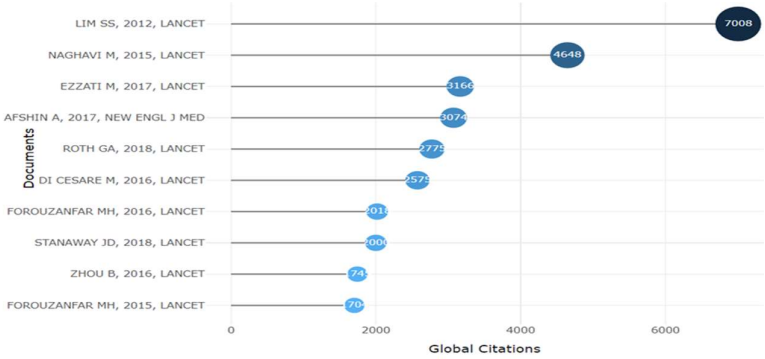



**Figure 7.** Top 20 most cited documents

## ❖ Co-occurrence Network

Figure 8 shows a graph of keywords used in the publications. Each node is associated with a keyword, and its size is proportional to the number of documents where it appears. Since the study focuses specifically on five countries, keywords, such as “Ghana”, “Nigeria”, and “Africa” were most recurrent. Climate change and machine learning adoption are the technical words with the highest weight. Machine learning, sensor networks, and artificial intelligence were the most explored digital agriculture technologies, and adoption was a significantly-discussed topic in the literature.

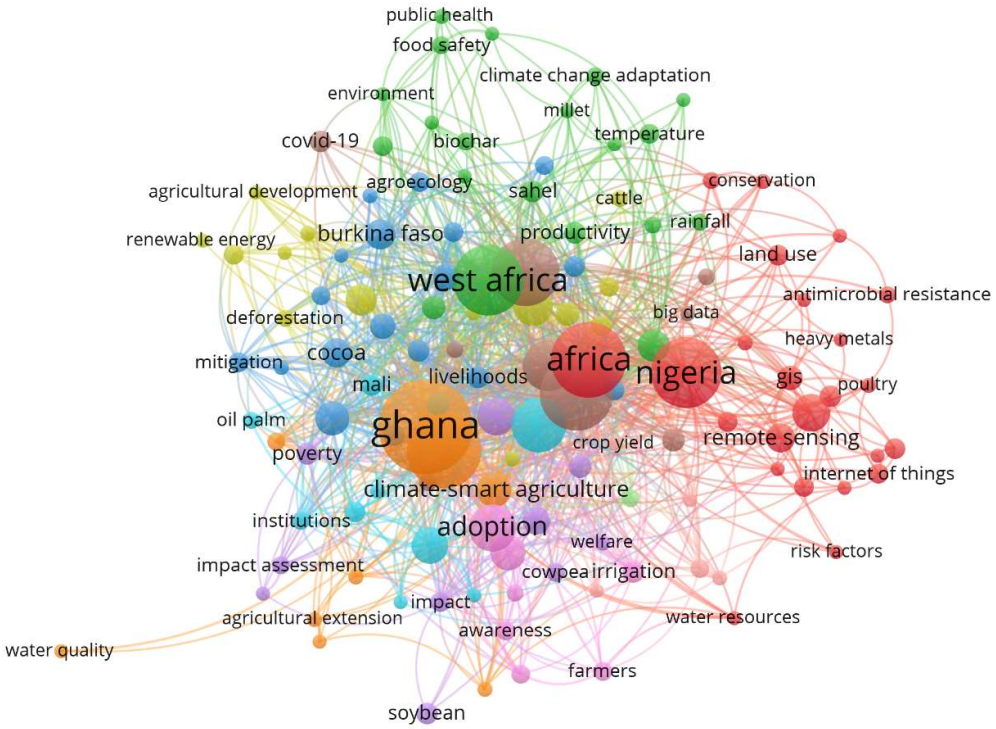



**Figure 8.** Co-occurrence Network

## ❖ Word Cloud

Figure 9 presents the most used words and topics in the publications. Agriculture, impact, system and adoption are the words with the highest occurrences. Overall, the ''impact of systems'', ''agriculture'' and ''adoption'' are topics of great interest in digital agriculture in West Africa.


**Figure 9.** Word cloud

## 3.2. State of the art of digital agriculture technologies in the AGriDI project host countries

A systematic review of agri-based innovations/technologies focusing on the AGrIDI project host countries, including **Benin, Burkina Faso, Côte d'Ivoire, Ghana and Nigeria, has** been conducted. During the last five years, many technologies have been the object of research to increase the agriculture sector performance, improve collaborative research and help small-scale production farmers and breeders in reliable production and remote field monitoring. As a result, there have been increased research efforts in developing agri-based innovations/technologies in many countries worldwide. However, there is a research gap in Africa. The leading technologies used in the five AGriDI countries are: The Internet of Things (IoT), Wireless Sensors Networks, Artificial Intelligence, Block chain, Unmanned Aerial Vehicle (UAV), Big data, and Geographic Information Systems (GIS). This section describes these technologies and presents their features.

An overview of the main characteristics of digital technologies and their applications in agriculture is provided. The following section presents a comprehensive analysis of the effective use of these technologies in agriculture in the five target countries.

### 3.2.1. Description of the digital technologies and applications in agriculture

- **Internet of Things (IoT)**

IoT defines a network of devices and sensors connected to the Internet. It refers to a network interconnecting ordinary physical objects with identifiable addresses that provide intelligent services. Two kinds of things are used in IoT. First, there are identified objects and, second, connected devices. The objects or devices can be connected to create a digital ecosystem and be connected to the Internet. The main features of devices used in IoT networks are:

- The ability to collect and transmit data;
- The ability to actuate devices based on triggers;
- The ability to receive information; and
- The ability to assist in communication.

The main components of IoT devices include the control units, the sensors, the Communication modules and power sources. The Internet of Things (IoT) can provide significant potential in smart Farming and precision agriculture applications, enabling the acquisition of real-time environmental data (Kuvoro et al., 2015). It represents Nigeria's leading technology most used during the last five years to improve the agriculture sector's performance.

- **Wireless Sensors Network (WSN)**

Wireless Sensor Network refers to a specific kind of IoT technology which contains many sensors that interoperate and can be connected to the Internet. These sensors, which previously were electromechanical detectors for measuring physical quantities,

have evolved into intelligent sensors, which now include an on-board processor, memory, and transceiver, all in a small-scale factor, powered by a battery source (Othman et al., 2015). These smart sensors constitute a node in the Wireless Sensor Network. The advantage of the small-scale node is two-fold: the low production cost and the easy and low installation cost. The benefit of the small-scale node is two-fold: the low production cost and the easy and low installation cost. These sensors are used for remote Livestock Monitoring and measuring environmental and soil parameters for irrigation system detection. Many applications of WSNs are made possible due to their characteristics. Remote sensing is considered a critical technology for monitoring cultivated fields.

- **Artificial Intelligence (AI)**

AI is a system that thinks like a human, acts like humans, reasons, or acts rationally. It is also defined as a program which, in an arbitrary world, will cope not worse than a human. AI is a set of programs with inputs and outputs and an environment. The application of AI in agriculture has been widely considered one of the most viable solutions to address food insecurity and to adapt to a growing population's needs. AI is applied in all countries (Figure 10) in various agricultural activities, including soil management, weed management etc.

- **Block chain**

Blockchain is a modern technology used in business transactions. Blockchain technology is part of industry 4.0, encompassing automation and data exchange in production processes. Blockchain technology is used in the agricultural sector to promote food security, prevent food fraud and verify the origin and authenticity of farm products and agricultural inputs. Transactions done with blockchain technology are secured with a digital, encrypted, tamper-proof signature, making them very difficult to change. Blockchain makes financial transactions possible while removing the need for intermediaries such as banks. This technology has been used for other purposes in agriculture, including supporting small-scale farmers in developing ICT E-Agriculture and ensuring food security and safety.

Food security is defined as the ability of an individual, at all times, to have financial, physical, and social access to safe, sufficient, and nutritious food, meeting their desire for special quality and the preferences of food for an active and healthy life. Also, it is helpful to have traceability of products when people purchase goods locally and hence are unaware of their origin or production footprints. When a product is traceable, retailers and consumers trust it more. For example, suppose the entire supply chain for agricultural products is embedded in a blockchain-driven ecosystem, from product registration and payment to transport and delivery. In this case, retailers can verify that the product they receive is what they paid for.

- **Unmanned aerial Vehicle (drone)**

Unmanned Aerial Vehicles (UAVs) are IoT devices exploited in various crop management applications by capturing high spatial and temporal resolution images (Tsouros et al., 2019). As highlighted in the IoT-related sub-section, IoT can provide significant potential in Precision Agriculture and Smart Farming, enabling a long-term increase in productivity. Besides applying remote sensing to monitor crop and vegetation parameters using wireless sensors, crop and vegetation parameters can also be observed through images at various wavelengths. This application uses satellite images or images acquired through human-crewed aircraft. But these methods present some shortcoming which induces the development of UAV-based remote sensing systems. Using UAVs to monitor crops offers excellent possibilities to acquire field data in an easy, fast and cost-effective way compared to previous methods.

- **Big data**

Big data technology applies serious computing power, the latest in machine learning and artificial intelligence, to seriously massive and often highly complex sets of information. It is also defined as a high volume, velocity and variety of information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making. This technology is used to analyze large volumes of data (like weather data) for actionable decision-making. Big Data differs from this historic information-gathering method regarding the importance and the analytical potential embedded in contemporary digital technologies. Big Data proponents promise the precision, information storage, processing and analysis previously impossible due to technological limitations.

- **Geographic Information Systems**

A geographic information system collects, stores, analyzes and graphically visualizes spatial (geographical) data and related information about necessary objects. The peculiarity of these systems is that they allow integration, maintenance and joint analysis of the most different types of spatially distributed indicators and descriptive data. These systems are used to create and maintain the land and water cadasters, property registers, environmental and weather monitoring, emergency management, production risk assessment, analysis of the interactions of various factors affecting crop yields, and many other applications based on spatially distributed information. The system's capabilities and flexibility ensure their applicability nationwide and at the individual farm level. GIS can be used to increase productivity and reduce fertilizer consumption.

### 3.2.2. Comparative analysis of technologies among the target countries for effective use of e-agriculture

To perform a comparative analysis of technologies used in the target countries, papers have been selected based on the previous bibliometric study. In total, 886 scientific documents (articles, communications, reports and preprint), including 547 documents

from the Web of Science and 339 documents from other sources, were retrieved. The documents were filtered based on the relevance of their title, abstract, keywords and conclusion to the topic of interest. In addition, only published papers during the last five years (2017 - 2022) were considered. This resulted in 40 scientific papers filtered and used in the comparative analysis of agri-digital technologies.

Nigeria is the country which registered many publications on this topic (mainly in IoT and Wireless Sensors Networks, block chain and AI). It is followed by Ghana, which has also published on the blockchain, AI and big data. On the other hand, when Burkina Faso and Côte d'Ivoire published respectively on IoT and AI, Côte d'Ivoire publications were only related to AI. Benin presents only one scientific applied publication associated with AI. Figure 10 summarizes by country the different technologies and their use case.

- In Benin, AI is used for crop production to predict soil properties.
- AI produces bananas, dry beans, cassava, rice, maize, and seed cotton production in Burkina. It is used to predict weather data and Chemical data. Also, IoT sensors are used for Fish species production, bananas and papayas production. They are used for sensing meteorological parameters, water pH, dissolved oxygen, temperature, and soil moisture.
- In Côte d'Ivoire, AI monitors riverine water and increases sugarcane production. In addition, this technology is used to manage and analyze weather data, chemical data, rainfall data, temperature data and sugarcane yields.
- In Ghana, AI manages soil water storage and crop yield prediction in landscapes. Big data is mainly used to collect data quality ownership and accessibility. Block chain handles coca food and drug supply chains for transparency, traceability, enhancement, and mitigation of unethical activities.
- In Nigeria, AI is used for livestock and crop management, water and soil management and breeding. Block chain is used to create digital trust between agriculture stakeholders. IoT sensor networks are used for livestock monitoring, remote control sensing, precision irrigation and triggering of automated irrigation systems. The smart village uses Lora for farm crops and water quality monitoring.

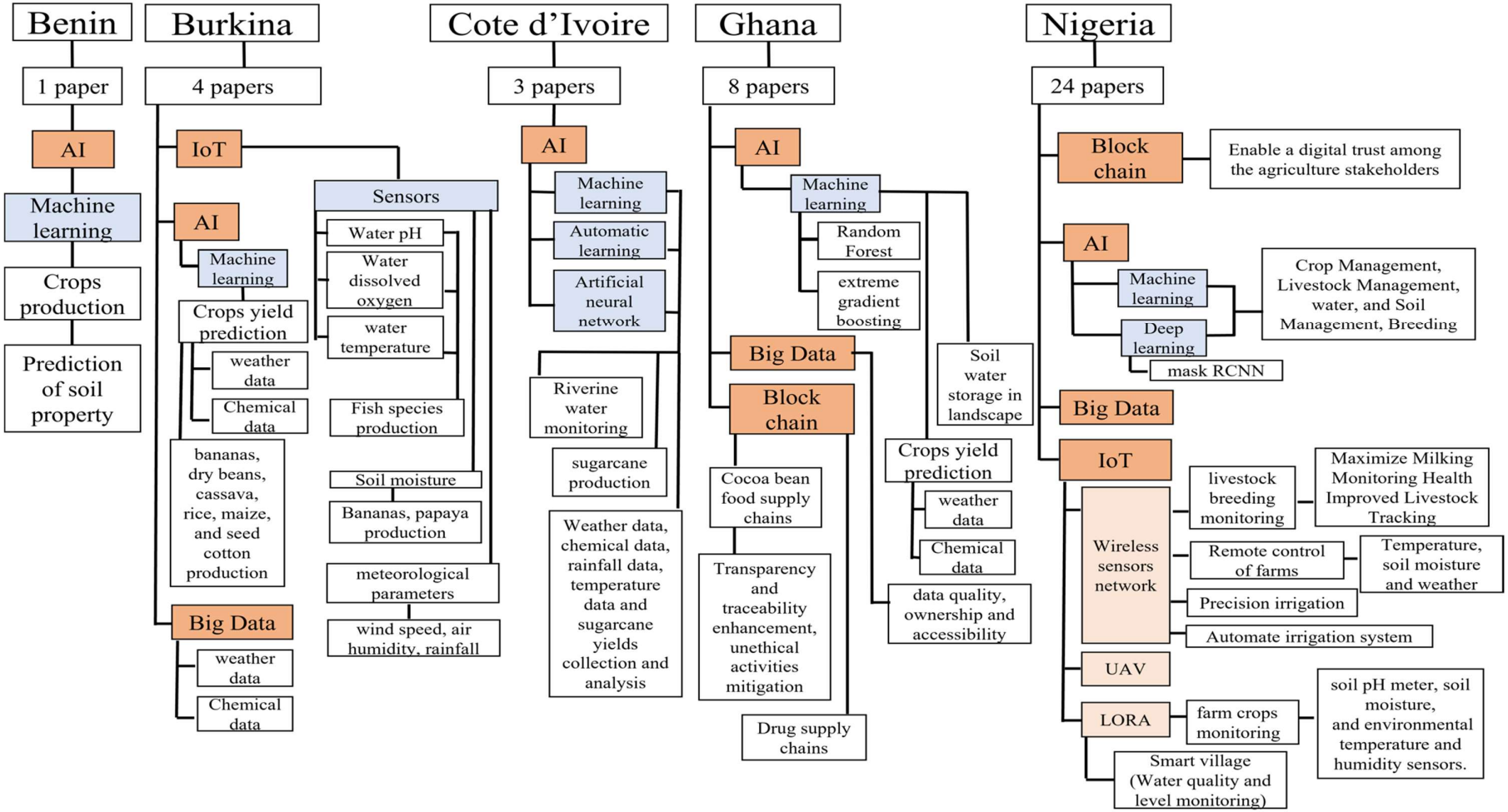



**Figure 10.** Overview of technologies used in Benin, Burkina, Côte d'Ivoire, Ghana and Nigeria and their applications

## 4. Inventory and description of the agri-based innovations in the five countries

### 4.1. BENIN

#### 4.1.1. E-Agriculture programs and projects in Benin

The Benin government has recently launched different programs to develop e-agriculture in the country.

- ***ACMA 2***, the Communal Approach for Agricultural Market phase 2 (Approche Communale pour le Marché Agricole phase 2; ACMA 2) was designed to benefit rural actors. The program uses ICT solutions to manage the identification of actors in the agricultural chain for networking, the collection of market information (SIM), e-commerce, the availability of educational content on good farming practices (SIFT), climate forecasts (Ignitia) and the digitization of agricultural financing.
- ***The Digital Rural Transformation Project,*** funded by the World Bank (World Bank, 2019) through an International Development Association (IDA) credit, contributed to increasing the productivity and competitiveness of two sectors identified as critical enablers of growth: agriculture and ICT. Focused on four value-chains: rice, maize, shea and vegetables, the platform enhanced access of smallholder farmers to information, financial services and markets, leading to an increase in productivity and sales and a reduction in post-harvest loss. It also helped Benin extend ICT connectivity and access to digital services in rural areas, including enhancing the metropolitan fiber optic loop in Parakou and the densification of the fibre optic infrastructure in downtown and the suburban regions of Parakou. About 1.6 million smallholder farmers benefited from the project, which impacted 560,000 workers associated with the four value chains. The project also supported the rehabilitation of rural roads.
- ***PARASEP***, the Support Project for the Strengthening of Private Sector Actors (PARASEP), is a project co-financed by the European Union and the French Development Agency (AFD). PARASEP was involved in developing two information and exchange platforms for actors in the agricultural system in Benin (***acteur-agricole.bj*** and ***agrizonecna.com***), which was launched on 31 March, 2021.

  -**acteur-agricole.bj** is a platform for producers. It also allows consumers to view the available products with their prices, and the agricultural service providers can sell their products and services for free through this platform.

  -**agrizonecna.com** allows anyone in need to identify producers and agricultural actors from different sectors as well as the organizations to which they belong throughout Benin and to be able to get in touch with them to buy their products

or to establish business relations with them. From this link, producers and farmers' organizations can find buyers or technical and financial partners to enable them to develop their activities.

### 4.1.2. E-Agriculture startups

- ***AgriLeap*** uses drones to take aerial views of fields. AgriLeap, created in 2018, is a solution implemented by a young Beninese to promote precision agriculture allowing crop planning from seed to harvest. The startup AgriLeap maps land plots and provides customers with the characteristics of their field, namely the different types of crops, their density, the water content, the need for fertilizer, etc. In addition, AgriLeap can also inform whether the crop adopted by its customers is adapted to the soil (Agridigitale, 2018).
- ***ICT4AGR-Bénin*** is a platform for the democratization of digital and electronic agriculture. Subsidized training in applying digital technologies and sciences to agriculture and related fields is offered to interested parties to build their capacity in these fields. The training components include Robotics in agriculture, Development of Android applications, Data access system, Statistical data processing, Computer programming, use of agricultural drones and Artificial Intelligence, Development of databases that offer farmers a reliable system for managing information, GIS and remote sensing, Internet of Things in Agriculture.
- **JINUKUN**[2] SARL is an agritech company that offers agricultural services and promotes access to agricultural products and local and farm food, improving the living and working conditions of local farmers and farmers. It has developed several e-agriculture innovations, which include
  - ***Jinukun Store*** is a BtoC e-commerce platform for marketing agricultural products from local farms and agri-food that includes a website (store.jinukun.com), a mobile application (under development) and delivery services and a network of franchises.
  - ***AgriConseils*** [3] assists its clients in setting up and managing their farms or production unit. The service is designed to consider the client's budget and provides technical assistance in the daily management of the activities for optimal production.
  - ***Jinukun Farmers*** provides a management and marketing solution to Beninese producers to produce and market their products more efficiently. The platform allows the farmer to follow the management of his farm at the operational, commercial and financial levels.

[2] https://jinukun.bj/
[3] https://agriconseils.jinukun.bj/

- **Tic-Agro Business Center** helps producers to access information on good agricultural practices and the availability of inputs. Its voice mail system allows the producer to receive voice messages in the local language on several topics, including those relating to climate change (Adjimehossou, 2021).
- **Center for Agricultural Promotion and Study of Livestock Adaptation to Climate Change (CEPACC)** offers a solution for managing farms remotely. The solution proposed by the startup allows using the computer to have an idea of each expense made, how the animals are fed, etc. (Adjimehossou, 2021)

- **E-agriculture solutions developed with ENABEL support**
  - ***E-conseil agricole*** (*Solution E-conseil agricole*), available since June 2021, the agricultural E-advice solution is based on the use of drones. Agents of the public sector agricultural council and private actors have been trained in using this solution, including the ATDA of poles 7, 6, and 5, Professional Agricultural Organizations (OPA), and technical departments of the MAEP. *E-conseil agricole* is a device made up of:

  - drones equipped with sensors for collecting image-type data from pineapple farms
  - software capable of interpreting drone images, in particular counting plants, flowers and fruits, delimiting the perimeter of the farm, determining the state of health of soil fields, water stress, nutrient stresses, level of disease attack and stage of maturity.
  - operators capable of preparing, performing field overflights, and presenting a farm status report.
  - ***Agriwallet***, this Innovation helps producers to receive payments from the aggregator (processing company) while having the possibility of gradually saving to buy inputs from a supplier. The solution also allows the signing and execution of smart contracts between actors in the same cluster (producers, processors, transporters, input suppliers, other service providers, etc.), making it possible to plan production, etc.

## 4.2. BURKINA FASO

In Burkina-Faso ICT and agriculture, initiatives cover many services of the agri-food systems (Figure 11), with the Multiservice (e-extension, Weather/Climate, SIM, Inputs, Precision Agriculture) and Market information (Price, Offer, demand) being the most common services.

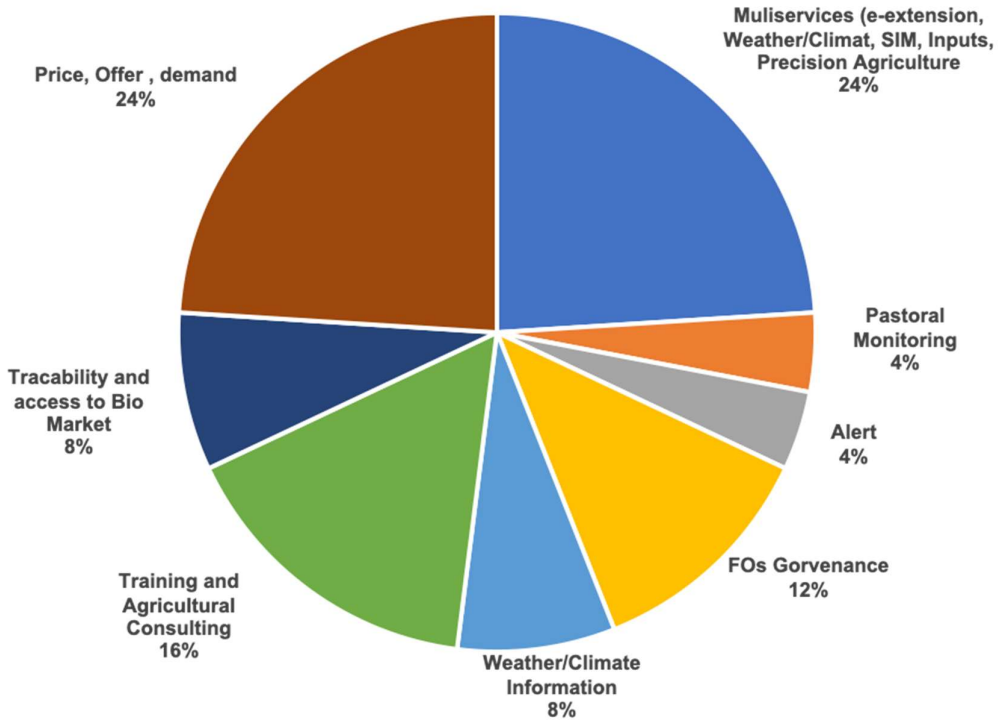



**Figure 11.** Distribution of the 25 "Digital for agriculture (D4Ag)" initiatives according to the services offered in Burkina Faso.

Source: Alexandre & Bationo, 2019

## E-agriculture innovations in Burkina-Faso

- ***Cocorico call center*** allows breeders to access information (produced in particular by satellite imagery) on transhumance corridors, the state of pastures and water points, and veterinary care. The EcoData company that manages the Cocorico call center also offers services, such as market research, surveys, etc., to POs or NGOs (Alexandre & Bationo, 2019).
- ***The Circle of Rabbit Farmers WhatsApp group*** allows the 250-member rabbit breeders to exchange information about inputs, diseases, feeding and breeding practices and sales (Alexandre & Bationo, 2019).
- ***Agri -Yaar*** is a web and mobile platform that connects rural supply to rural demand. This platform is available at: http://www.agriyaar.com/. Agri-Yaar's service offers are essentially based on linking agricultural cooperatives. To offer this service, Agri-Yaar also uses Facebook in addition to its web platform (Yam-Pukri, 2020).

- ***La cause rurale***[4] is a magazine which promotes agro-sylva-pastoral, fisheries and wildlife activities. In addition to its website, this magazine also has a Facebook page and an online library that provides more than 2000 documents for anyone who wants information on legal texts and Agriculture (Yam-Pukri, 2020).
- ***Yam Pukri*** **association** is a pioneer organization in Francophone Africa regarding training, information, support and advice in information and communication technologies. Yam Pukri has developed Agricultural ICT platforms: *Vacis-bf* (management of agricultural value chains), *Pro impact* (project capitalization software), *Agrico* (management of cooperatives: members, contractualization), *Abac Infos* (Android application for training in cereals (production, conservation, etc.).
- ***Farafina Agri-Funding*** is a social enterprise working to develop agriculture in Burkina Faso through a digital crowdfunding platform created in 2019. The company equips and raises awareness, both media men serving as relays and actors in agricultural entrepreneurship on its digital crowdfunding platform Farafina Agri-funding (Barry, 2022).
- ***Ouaga Lab*** is an incubator in the field of technology in Burkina and has developed several drones for farmers. These include, for example, "*agri-alert*" to monitor and send alerts when locusts, army worms and seed-eating birds attack fields. There is also an "*agri-drone*" to capture the humidity level of the fields.

## 4.3. CÔTE D'IVOIRE

### 4.3.1. E-Agriculture projects

***Project of Digital Solutions for Opening up and e-agriculture:*** A digital agricultural platform has been created as part of the Digital Solutions of the Project for opening up and e-Agriculture (PSNDEA). This platform has allowed all remote producers to provide information on good farming practices through digital means. Capitalizing on the experience in electronic agricultural advice and its territorial representability, the National Agency for Rural Development Support (ANADER) has been designated by the project for the animation of the platform and the identification of relay points and managers of Professional Agricultural Organizations (OPA). The project through digital channels such as SMS, mobile applications, web service and telephone call center to provide all farmers with digital agricultural advisory services, agro-meteorological advice, physical support proximity to the operationalization of the ecosystem for marketing agricultural products such as rice, and corn, cassava, yams, plantains, market garden crops, shea butter, traditional chicken, guinea fowl (ANADER, 2021).

[4] www.lacauserurale.com

❖ ***Project "e-agriculture"***

In line with the National Agricultural Investment Program (PNIA) and the Government's strategy for e-agriculture (2016-2019), the "e-agriculture" project funded by the World Bank supported 6.1 million smallholder farmers to quickly access critical information for their business, including prices on the seed market. The project also provides the Ivorian authorities with reliable data to better manage their policies and strategies favouring agriculture and the rural world (gouv.ci, 2018).

### 4.3.2. E-Agriculture Platforms and Startups

- ***The platform Buy From Women "Blaatto[5]"***, the digital platform launched in March 2022 by UN Women, helps women farmers to find markets for their crops. Blaatto Buy From Women is an open-source, cloud-based enterprise and e-commerce platform that can be customized to specific market products. It also offers women information and finance (AfDB, 2022).
- ***ICT4Dev startup***, through its Lor Bouor project, offers a variety of solutions and services ranging from the provision of voice information to the provision of agricultural marketplaces. Lôr Bouôr consists of 5 services combining agriculture and ICTs (Palmafrique, 2014a; Lôr Bouôr, 2022). These include:
  - GELICO [6](Online Management of Agricultural Cooperatives): a web management platform at the service of agricultural cooperatives (Identification of members, plots, production flows, accounting management, etc.);
  - "*Anikogoh*": an information website[7], training, networking and promotion of ideas and initiatives dedicated to actors and initiatives in the agricultural world;
  - "*Djori Djori*" Market Information System (SIM): an SMS and mobile application for disseminating and consulting the prices and trends of agricultural products on urban and rural markets;
  - "*Djassl*": a voice kiosk with Call back system for the dissemination of agricultural information (prices, weather, cultivation techniques, advertising, etc.) in the local language;
  - *Virtual Market*: this is a virtual platform for exchanges between sellers (agricultural cooperatives and wholesalers) and customers. This virtual Market is based on a mobile application (Web) and SMS, which makes it

[5] https://blaatto.com/
[6] www.gelico-ci.org
[7] www.lorbouor.org

possible to publish or consult information on the Market. It is coupled with an information alert system on market availability regarding supply and demand.

- ***The integrated digital platform Wi-Agri*** answers challenges hampering the sustainability of cashew activity. The integrated digital platform Wi-Agri allows members of the cooperative to map their plantations, reconstruct the path of their products, production to distribution, and, better still, to get paid by mobile money. To date, the platform has registered 2,000 small producers, buyers, cooperatives and SMEs out of a target of 25,000 by the end of 2022. In addition, the monthly subscription fee to the platform amounts to 200 CFA francs (Cio Mag 2022).
- ***M-Agri,*** an initiative of Orange Côte-d'Ivoire, provides updated prices of several agricultural commodities, with trends and strategic advice. The service is the solution for producers and buyers of agricultural raw materials who lack information regarding commercial risks such as rise or fall in prices, stock levels, the intensity of transactions, etc. (Orange.ci, 2016). M-Agri allows one to stay informed of news from many commodity markets (rice, maize, onion, cassava, banana, cocoa, cashew, shea, sesame, rubber, millet, sorghum, etc.) and to receive general news from the agricultural sector (weather, events, public announcements, etc.) and technical advice (fertilizer management, environmental protection, best practices, etc.). The M-Agri subscription costs 103 CFA francs per month.

## 4.4. GHANA

### 4.4.1. Overview of Ghana E-Agriculture Programme

The components of the E-Agriculture Programme Platform in Ghana include the following:

- ***E-Farm Information (Farmer Audio Library/Interactive Voice Response System [IVR])***, where an interested person calls a specific toll-free line and is taken through the procedures of the desired crop/animal production in their local languages, anywhere and at any time.
- ***E-Field Extension***, where extension officers are equipped with modern technologies and applications to provide accurate and prompt responses to field needs and early control systems to safeguard food security. This service has a Call Centre, where the public can call the toll-free line and get information about agriculture in local languages.

- *E-Learning and Resource Centre*; this is composed of a center for information and technology training to promote youth in agriculture and a Web Portal for publishing news and current activities in the agricultural sector.

### 4.4.2. E-agriculture startups

- *TechShelta,* is a service-oriented company that provides a suite of web and mobile-based applications that enable farmers to have on-demand access to advisory, automation, management, training Market linkages opportunities, and inputs for greenhouse production. In addition, TechShelta offers a subscription-based model service to its clients across Ghana. The service remotely controls existing manual operating systems, such as irrigation, temperature and humidity, with the aid of Internet of Things (IoT) devices. TechShelta also organizes Farmer Field Schools (FFS) and Competency Based Training (CBT) for farmers and youth.

- *Cowtribe*, established in 2016, helps farmers fight livestock disease. Cowtribe has developed a digital on-demand and subscription-based service which delivers livestock vaccines to rural farmers (Spore, 2019). The system also allows farmers to track the health of each animal and reminds them when their animals need veterinary services.

- *TROTRO Tractor Limited* is an African youth-led initiative using the Internet of things (IoT) and technology to make agricultural mechanization (Tractor) service available, accessible, and affordable, and to enhance productivity and efficiency and reduce post-harvest loss. The farmer can request, schedule and prepay for tractor services through this platform. The platform also allows tractor owners to monitor their equipment's movement and work progress.

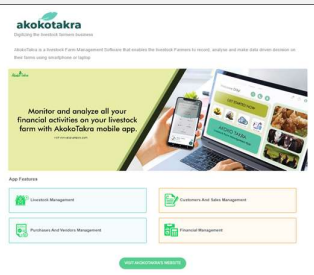
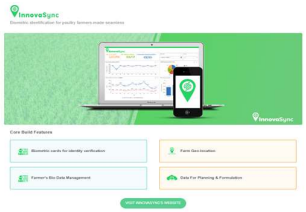
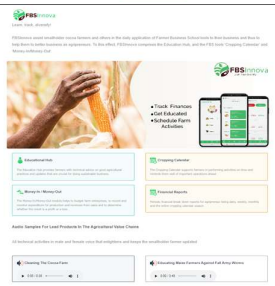
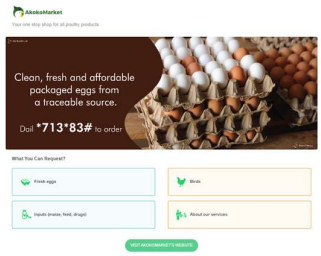
- *Esoko*[8] has helped enterprises manage rural communities since 2008. Traditionally focused on content services to farmers, the platform now provides powerful data collection & digitization tools, biometric profiling, analytics, and communication services. Esoko has introduced services like digital credit, insurance, payments and transaction services. The startup is helpful to anybody who is looking to profile or register people, digitize agric supply chains & social protection programs, conduct GIS mapping, or track inventory or impact, or anybody who wants to engage communities with critical information campaigns like healthcare, agronomic advisories, climate-smart contents, weather, nutrition or Market information.

- Agro Innova[9] is an Agri-Tech Company with the primary objective of using digital technologies to address challenges faced by smallholder farmers and the entire

[8] https://www.insyt.esoko.com/
[9] https://agroinnovagh.com/index

agriculture value chain players. Agro Innova deploys a suite of software tools and technology-enabled platforms which help to streamline business across Africa's agricultural industry. The company has developed several e-services (Table 1).

**Table 1.** List of some e-services provided by Agro Innova startup

| E-services | Description | |
|---|---|---|
| **AkokoTakra**[10] |  | A livestock Farm Management Software |
| InnovaSync[11] |  | Biometric identification for poultry farmers made seamlessly |
| FBSInnova[12] |  | It helps smallholder cocoa farmers and others in the daily application of Farmer Business School tools to their business and thus to allow them to better business as agripreneurs. |
| AkokoMarket[13] |  | The stop-shop for all poultry products where you can get clean, fresh and affordable packaged eggs from a trackable source. Orders can be made via *713*83#. |

- ***TradeNet.biz***[14], developed by a team of young Ghanaians at BusyLab, a software research and development business based in Accra, Ghana, is a customizable, web-based platform (Figure 12) offering online tools for the exchange and management of market information. It offers:

[10] https://akokotakra.com/
[11] https://agroinnovagh.com/product#
[12] https://fbsinnova.com/
[13] https://www.akokomarket.com/
[14] http://www.tradenet.biz

-Six modules for managing price information, document library, news, offers, contacts, and commodity information;

-Space for producer and trader organizations to create websites which can incorporate information from the above six modules;

-Access to information using Short Message Service (SMS) available on digital mobile phone networks;

-Facilities for users to configure local measures, i.e. sacks, bowls, bags, etc and specify a metric conversion and upload or display prices in local measures.

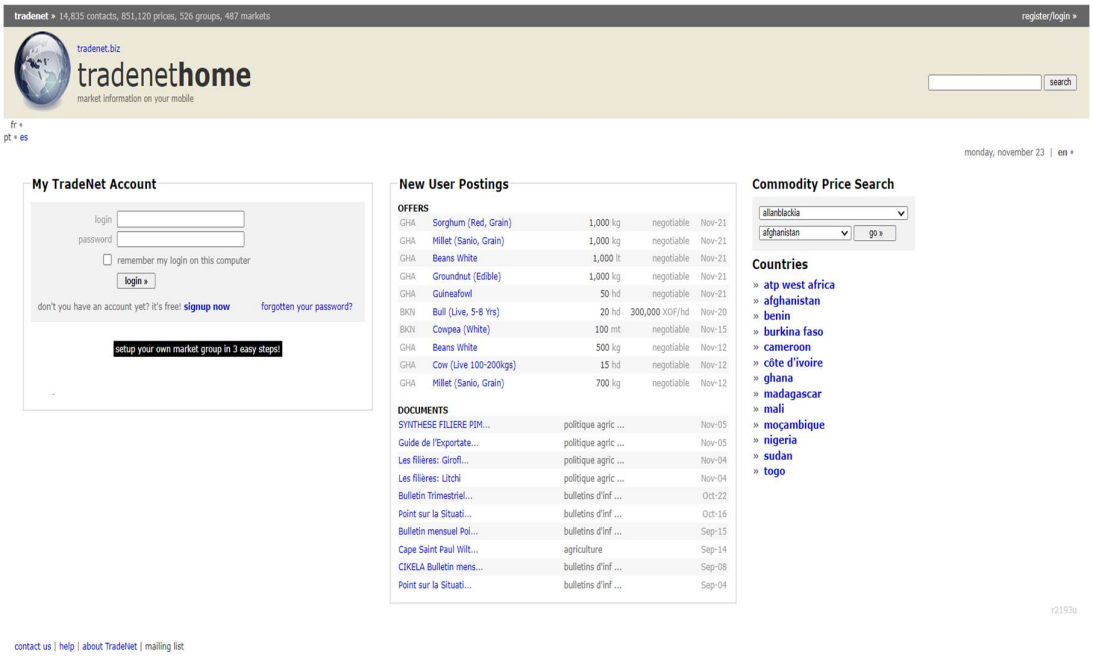



**Figure 12.** TradeNet.biz15 web-based platform

## 4.5. NIGERIA

ICT has been used in a variety of ways for extension service delivery in Nigeria, and these include radio, TV, call centres, phone applications, and tablets (Figure 13). Hence, Nigeria continues to invest in skills and entrepreneurship, stimulating the development of high-growth AgTech companies. It has a vibrant ecosystem of incubators, accelerators, digital startups, and investors for digital agriculture.

[15] http://www.tradenet.biz


**Figure 13.** Application of ICT in efficiency and productivity measurements in Nigeria

Source: Adopted from FAO / ITU, 2017

### 4.5.1. E-Agriculture Platform

❖ **Government platforms**

- ***The national e-agriculture web portal (NEAWP)***

To ensure all information and data about agriculture in Nigeria are available to Nigerians and the international community, the Federal Government launched in October 2016 the national e-agriculture web portal (www.eagriculture.gov.ng/eagricportal/). It is a strategic initiative designed to enhance the knowledge flow between stakeholders and ensure inclusive and robust development of the agricultural sector. It also aims to highlight the strategic and operational components of Nigeria's ICT-driven agricultural value chain, especially as it relates to the recently launched Green Alternative policy. To this end, the NEAWP integrates all existing and future agricultural platforms and mobile applications to create a one-stop national e-agriculture presence.

- ***Federal Government "e-wallet" program***

The Federal Government of Nigeria (FGN) 2012 launched the growth enhancement support scheme (GESS) to transform the delivery of agricultural inputs in the country (Uduji et al., 2019). Under the GESS, the FGN's role shifted from direct procurement and distribution of information to facilitation of procurement, regulation of the quality, and promotion of the private-sector input value chain (Figure 14). The mobile phone (electronic wallet system) is at the heart of technology applications under the GESS.

The e-wallet system technology ensures that a Nigerian farmer receives farm input subsidy support from the FGN through accredited agro-dealers, provides important agro-information alerts, is available to the agricultural extension system, and facilitates microlending and insurance schemes. The rapid adoption of the e-wallet program has generated much speculation and optimism regarding its effect on economic development in the country.

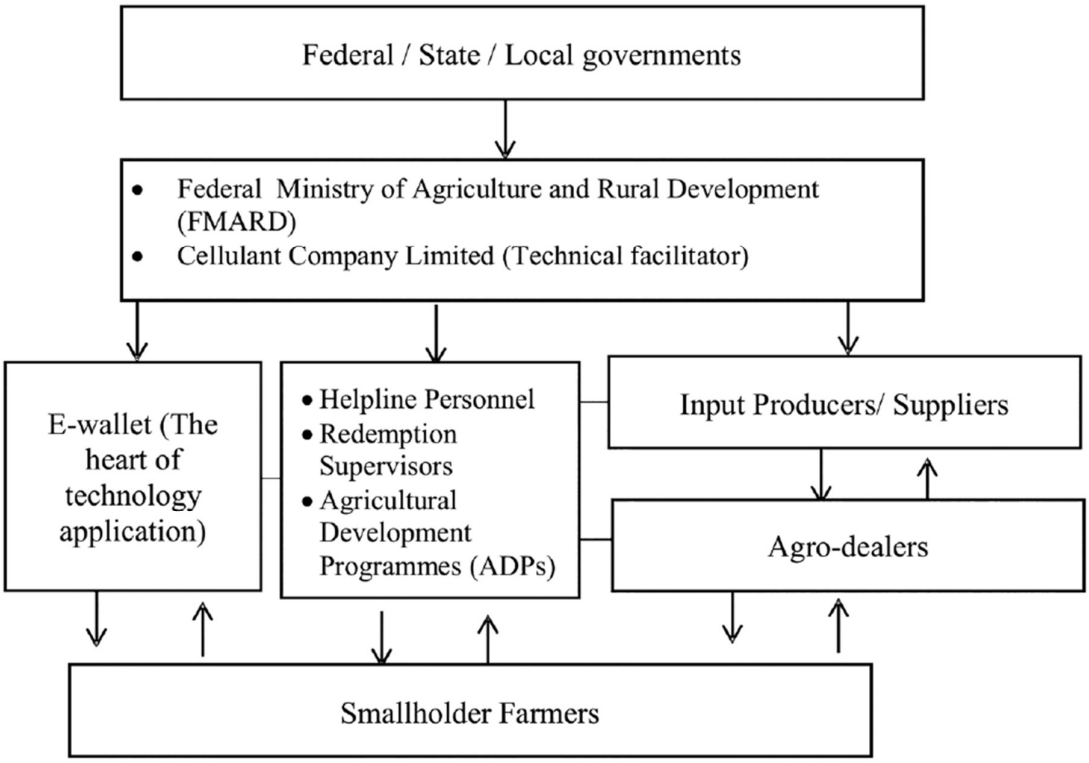



**Figure 14.** The structure of the growth enhancement support scheme operation

Source: Uduji et al., 2019

- *Cost-effective agricultural information dissemination system (AgrIDS)*

Nigeria has designed and implemented a cost-effective agricultural information dissemination system (AgrIDS) to disseminate expert agriculture knowledge to the farming community to improve crop productivity. The proposed system (WAP E-Farming System) aims to improve agricultural productivity by spreading fresh expert agricultural advice through text and images on the Internet to the farmers.

The proposed system has a Decision Support Software (DSS) application running on both Internet/mobile telephony platforms using Web 2.0 tools and other GSM services such as the SMS (short message service) for the dissemination of information to both farmers and extension workers. WAP E-Farming System offers instantly to its users after registration a different range of products such as news,

finance, tractor hire enquiry, fertilizer application enquiry, and herbicide application enquiry (Figure 14).

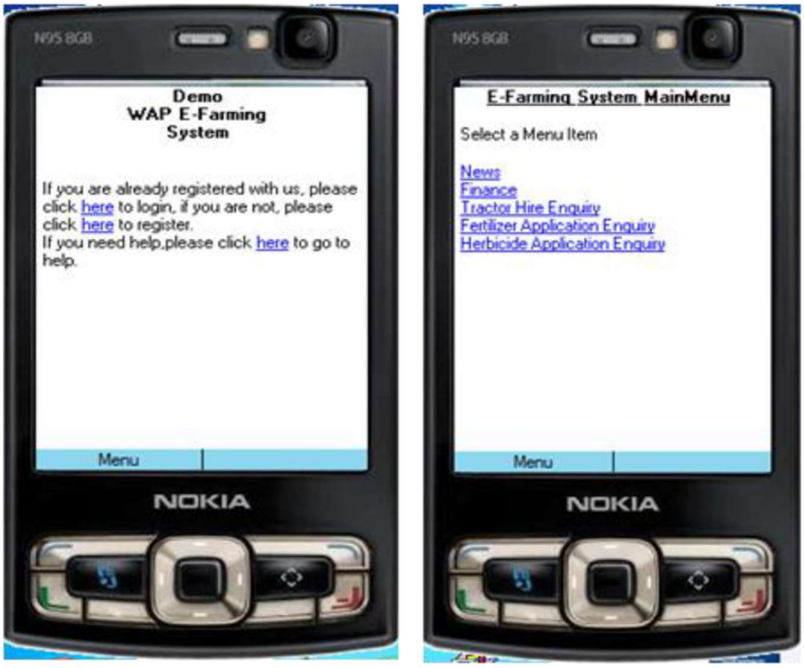



**Figure 15.** WAP E-Farming System

Source: Uduji et al., 2019

❖ *Private sector platforms*

- **Afrimash**[16] is a digital platform that efficiently connects farmers to quality inputs (e.g., poultry, fish, livestock, crops, farm inputs, and farm equipment) through verified suppliers via the Internet and mobile phones across Nigeria. Afrimash facilitates farmers' access to information and provides them with online training to improve their practices, productivity, and profitability.
- **Livestock247**[17] is a multi-stakeholder (buyers, sellers, ranchers, merchants, veterinary professionals, butcheries/abattoirs, logistical services, and financial service providers) platform. It promotes cost-effectiveness, convenience, and quality throughout the livestock value chain. The system is endowed with a unique traceability system for healthy cattle sales, reducing the risk of zoonoses, and developed meat sales with complete traceability, safety, and structured markets for wholesale and retail consumption.

[16] https://www.afrimash.com/
[17] https://livestock247.com/

## 5. Digital Agriculture policies and strategies among the five countries

### 5.1. Status of infrastructure for the digital agriculture

The ability to use digital technologies in agriculture depends not only on access to basic connectivity infrastructure (broadband, telecommunication services, etc.), the development of data collection and analysis services, and the regulatory environment (OECD, 2019). In this section, we present the status of key enabling factors, including policies and regulations for the smooth and increasing deployment of digital technology into agriculture in the five target countries.

An overview of the Mobile Connectivity Index indicated steady progress (Figure 15) in key enablers of mobile internet adoption (infrastructure, affordability, consumer readiness, and content and services) in all five countries. Efforts to increase GSMA Mobile Connectivity in the five countries reflect the trends reported in the West Africa region (Tossou et al., 2020), with none of these countries having an MCI above 60, suggesting there is still a big gap to fill. Ghana and Nigeria have the highest MCI followed by Côte d'Ivoire, Benin and Burkina-Faso. A commitment to increasing mobile internet adoption is observed in Benin and Burkina-Faso, with an increase of 12.5 and 8.34 points in their MCI between 2017 and 2021 compared to approximatively 7.7 points in other countries (Figure 16).

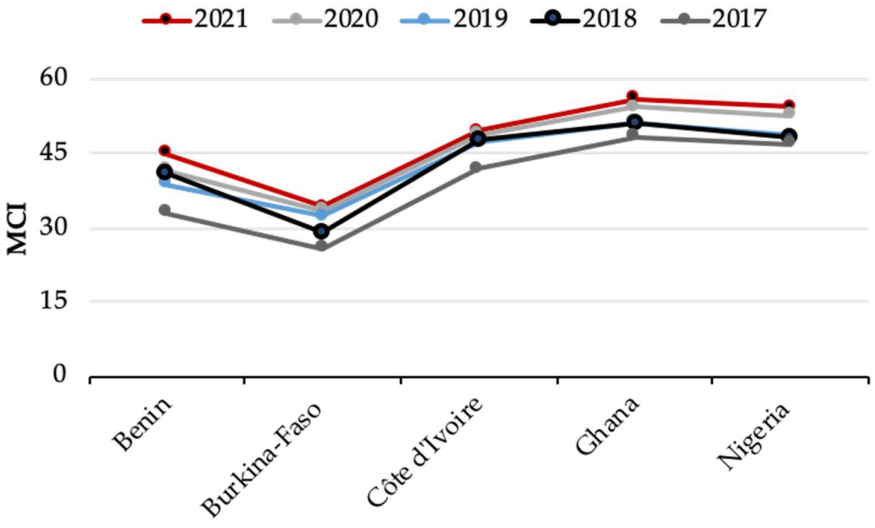


**Figure 16.** Trends in Mobile Connectivity Index18 (MCI) in the five AgriDI target countries

Regarding infrastructure, electricity and the Internet are the fundamentals of digital agriculture. According to the World Bank statistics (Figure 17), above 50% of the population in Ghana, Côte d'Ivoire, and Nigeria have access to electricity as opposed to Benin and Burkina-Faso. Most of these people, however, live in urban areas, with low access to electricity in rural areas in all target countries except Ghana (74%) and Côte d'Ivoire (42%). Similarly, the internet connectivity in Benin, Nigeria and Burkina-Faso still reflects the trend in West African countries, while the other two countries, especially Ghana, are keeping pace with the world (60%), with 58% of its population using the Internet (Figure 18).

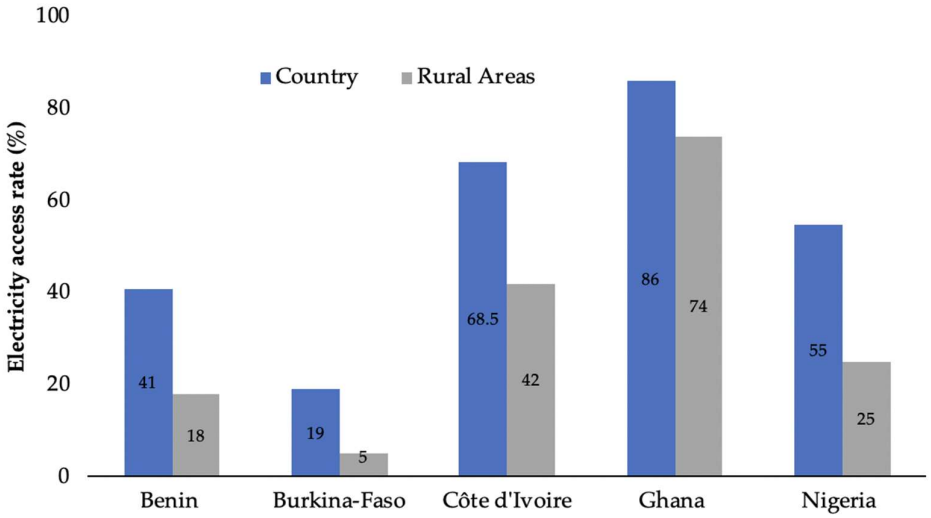
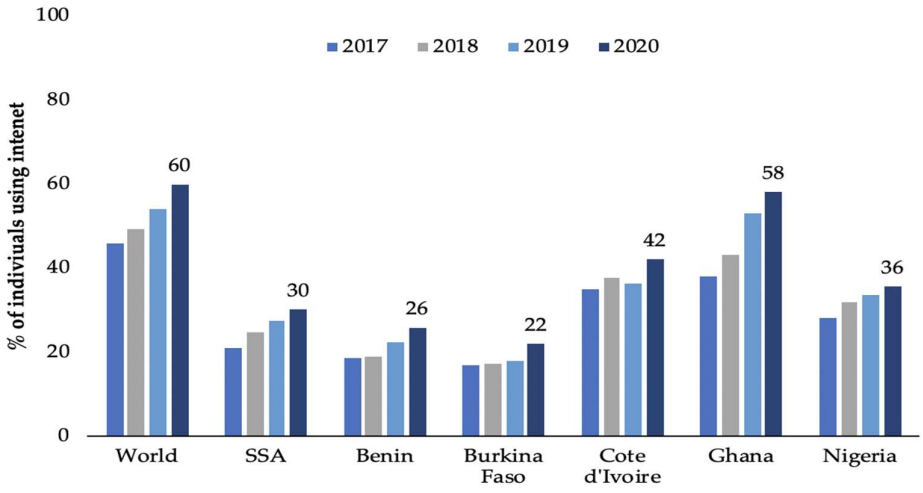



**Figure 17.** Electricity access rate in the five AGriDI target countries by 202019




[18] https://www.mobileconnectivityindex.com

[19] https://trackingsdg7.esmap.org/

**Figure 18.** Internet use rate20 in the five AGrIDI target countries

The differences in the development of crucial infrastructure among the target countries result from the individual country's efforts to promote a conducive environment, including policies and regulations for digital agriculture. According to FAO (2017), a comprehensive national strategy can prevent e-agriculture projects from being implemented in isolation, avoid duplication of efforts and resources, and develop efficiency gains from intra-sector and cross-sector synergies. A country-based analysis revealed that all five countries had acknowledged the need to create a digital economy and are working to develop different strategic documents. However, except for Benin (MAEP et al., 2019) and Nigeria (NITDA, 2020), which in addition to other documents on digital economy policies and regulations, have already developed a separate document depicting the roadmap for Digital Agriculture, the other countries are either working to establish one or they have it embedded in their national development plans.

**Table 2.** Status of the national digital agriculture strategy

| Countries | Recognizing the need for action | Formulating the plan | Validation Phase | Implementation Phase |
|---|---|---|---|---|
| Benin | ✓ | ✓ | ✓ | ✓ |
| Burkina-Faso | ✓ | | | |
| Côte d'Ivoire, | ✓ | ✓ | ✓ | |
| Ghana | ✓ | ✓ | ✓ | ✓ |
| Nigeria | ✓ | ✓ | ✓ | ✓ |

- Indicates the step is done or underway

## 5.2. Overview of strategy and policies of digital agriculture

### 5.2.1. BENIN policies and strategies for digital agriculture

In Benin, the overall strategy and development of digitalization is led by the Ministry of numeric and Digitalization (Ministère du Numérique et de la Digitalisation, MND) in collaboration with agencies such as the Electronic Communications and Postal Regulatory authority (ARCEP), the Beninese Agency for the Universal Service of Electronic Communications and Post (ABSU-CEP), the Digitization and Digital Agency and Services and Information Systems Agency.

The country's agricultural policy is mainly implemented through the Strategic Plan for the Development of the Agricultural Sector (Plan Stratégique de Développement du Secteur Agricole – PSDSA), which defines four interventions axes/pillars closely linked with the Government Action Program (MAEP, 2017; Presidency of the Republic of Benin, 2021). Through its Action Program 2016-2021, The

[20] https://databank.worldbank.org/reports.aspx?source=2&series=IT.NET.USER.ZS&country=#

Benin government intends to "transform Benin into a digital service platform for West Africa to accelerate growth and social inclusion by 2021". Since 2019, The Benin government has begun mainstreaming digital agriculture into national agriculture development, including developing the national digital agriculture strategy (MAEP et al., 2019). The political framework of this strategy is anchored on four specific axes: i) improving governance and information systems for the agriculture, food security, and nutrition sector, ii) establishing an e-Agriculture governance entity that will oversee the implementation of the e-Agriculture strategy, iii) strengthening the existing framework of key policies, legislation, regulations, and guidelines for e- Agriculture and ensure its effective implementation, and iv) establishing an agricultural information system for monitoring and evaluation.

The Government has deployed an inclusive approach involving government representatives and other key stakeholders to ensure that gaps in capacity building for e-agriculture are identified based on the state of ICTs and the needs on the ground (MAEP et al., 2019). Among the various reforms in this sector is the creation of the Direction of Information Systems within the Ministry of Agriculture, Livestock and Fisheries (MAEP) the agricultural digitalization (FAO & ITU, 2022) to promote the digitization of farming activities. Furthermore, the new Drone-Assisted Land Mapping for Climate Smart Cashew Production initiative will help farmers adopt climate-smart agriculture through drone technology (FAO & ITU, 2022).

### 5.2.2. BURKINA FASO policies and strategies for digital agriculture

In Burkina-Faso, the Ministry of the Digital Economy and Posts ensures the implementation and monitoring of the Government policy for developing telecommunications/ ICT, digital economy and postal services.

Integration of ICTs in the agricultural sector in Burkina Faso began with the structural adjustment programs of the 1980s-1990s (Alexandre & Bationo, 2019). These experiments focused on Market Information Systems (MIS), designed to improve the link between production and the Market and ensure a fair distribution of profits within the sectors. In the decade 2000-2010, NGOs, private companies and producer organizations (POs) gradually became interested in the potential of ICTs for agricultural advice.

The Burkina Faso government adopted 2018 a national strategy for the development of the digital economy (2018–2027) to improve infrastructure, promote digital technologies, and the transformation of all productivity sectors, including Agriculture, the primary source of livelihood and a pillar of the national economy (MDENP, 2018). However, the national digital agriculture policy is still not yet developed, suggesting that the country has to connect agriculture and ICT industries (FAO & ITU, 2022). The country possesses a Climate-smart agricultural investment plan that identifies big data, remote sensing, GPS, barcoding, and blockchain as promising

e-technologies for digitalisation of Burkina Faso's agricultural sector (World Bank et al., 2020).

### 5.2.3. CÔTE D'IVOIRE policies and strategies for digital agriculture

The Ministry of Digital Economy and Post champions the national strategy for digital economy development. In 2012, the National Agency for the Universal Service of Telecommunications (NASUT) was created to implement the country's digital strategy and spread ICT use and adoption (FAO & ITU, 2022). In 2015, the Agricultural Orientation Law was voted to provide the regulatory framework for all agricultural activities, and regulation is also in place for general ICT activities (Traore et al., 2021).

The significant development in digital infrastructure in the country was the result of key policy reforms, especially the 2012 Digital Solutions Program for e-Agriculture and the Opening of Rural Areas (PSNDEA), which realigned telecommunications laws with regional priority issues and defined a national strategy for digital solutions in agriculture and rural areas (Traore et al., 2021). The PSNDEA aimed at reducing the digital divide by providing connectivity in rural areas while providing digital services to rural communities to improve their agricultural value chain (FAO & ITU, 2022). Another strategic document is the second iteration of the National Agricultural Investment Plan (PNIA II), which provides an additional framework for public programming and private investment in the agricultural sector and aligns well with PSNDEA in digital agricultural Innovation. Specifically, it addresses electronic producer profiling, geolocation projects, and technologies such as GPS, satellites, smartphones, etc. (MADR, 2017).

Some government initiatives include the Agro-Industrial Pole Project in the Bélier region (2PAI-BELIER), initiated in 2016 with the technical and financial support of the AfDB, which promoted ICT-led agro-industrial transformation in the central part of the country. Furthermore, as of 2021, the Government worked on smart agriculture and technological Innovation with La Recherche Agronomique pour le Développement and Agence Français de Développement. In 2019, the Government announced a living income differential to be paid for every tonne of cocoa procured, reforming production and pricing in the farmers' interest, and making a strong case for digital procurement. As a result, in 2019, the country was ranked 172 globally in the UN's E-Government Development Index, placing it highest among the ECOWAS countries (FAO & ITU, 2022).

### 5.2.4. GHANA policies and strategies for digital agriculture

The Ministry of Communication and Digitalization, established under section II of the Civil Service Law, 1993 (PNDCL, 327) as amended by the Civil Service Act, 2001, has the core mandate of initiating policies to enhance information and communication infrastructure and service delivery in Ghana. Regarding digitalization and ICT services, Ghana's ICT for Accelerated Development (ICT4AD) Policy, the National Broadband Policy and Implementation Strategy, Ghana's National Cybersecurity Policy & Strategy and Digital Financial Services Policy are some recent policies enacted to streamline developments in the ICT and telecommunication sector.

Launched in 2003, the ICT for Accelerated Development (ICT4D) Policy aims to develop Ghana's information society and economy (the Republic of Ghana, 2003). It pursues a multi-sectorial ICT-led socio-economic development goal to establish Ghana's ICT sector using ICTs as broad-based enablers of the country's development goals. In agriculture productivity, one of the 14 pillars of the ICT4AD policy focuses on the modernization of agriculture and the development of an agro-business industry. Ghana's 2012 broadband strategy also sought to: establish a relationship between broadband policy and universal access policy to make broadband policy universal by 2015; facilitate affordable access to broadband infrastructure for all by 2015; ensure last-mile connectivity to communities and homes by 2020, and promote uptake of broadband via suitable content and applications and plan towards converged infrastructure and service delivery. To that end, a board was set up to establish synergies between the policy and critical sectors such as agriculture.

The country also successfully launched a national cybersecurity policy in 2014, with food and agriculture highlighted as one of the critical national information infrastructure areas vital to the nation, which, if incapacitated, could have devastating economic outcomes on the economy. The Ministry of Food and Agriculture is developing a digital agriculture policy, strategic plan and action plan to guide the implementation of e-agriculture in the country. The Ministry is coordinating and harmonizing all the ICT initiatives (private and public) within the agriculture sector to ensure synergy and avoid duplication. The core function of the Ministry is to render agricultural extension services and other advisory services to actors along the agricultural value chain. To this end, a 10-year Digital Agricultural Advisory Service Strategic Plan is being developed to lead implementation (FAO & ITU, 2022).

### 5.2.5. NIGERIA policies and strategies for digital agriculture

With the largest mobile market in Sub-Saharan Africa supported by mobile solid broadband infrastructure and connectivity, Nigeria has a high potential to enhance agriculture and food systems and employment through a robust digital ecosystem. In 1992, the National Broadcasting Commission (NBC) Decree 38 and the Nigerian Communications Commission (NCC) Decree 75 changed the ICT environment permanently. Both decrees began to open the broadcasting and telecom markets. Nigeria produced a national ICT policy in 2012 through the Federal Ministry of Communications (FMC). It formulates policy on communications, while the Nigerian Communications Commission (NCC) implements telecommunications policies. In 2015, the Nigeria Communications Commission's (NCC) 8-Point Agenda proposed the transition of Nigeria into a digital economy through investment in digital infrastructure and, more specifically, broadband.

The National Information Technology Development Agency (NITDA) was created in April 2001 to implement the Nigerian Information Technology Policy and coordinate general IT development in the country. Nigeria recently developed the Nigeria Digital Agriculture Strategy (NDAS) as a ten-year (2020–2030) plan that provides purpose and direction for adopting digital technologies in agriculture (NITDA, 2020). In the

agriculture sector, from 2011–2015, the Nigerian Government implemented the Agricultural Transformation Agenda (ATA), which sought to support agriculture by introducing business-like practices. Following the ATA, the Government launched the Agriculture Promotion Policy (APA, 2016–2020) in 2015, reiterating the necessity of deploying digital technology in agriculture. This policy document highlighted two important areas in which digital technology can be used to address gaps in agricultural growth: i) agricultural land management with the use of digital tools for farmer and land registration and web-based mechanisms for verifying land titles, and ii) building the capacity of research communities to leverage digital technology to reduce the cost of fieldwork.

To enhance local trade and exports, the Government has introduced some policies and programs: Nigeria–Africa Trade and Investment Promotion Programme, Presidential Economic Diversification Initiative, Zero Reject Initiative and Economic and Export Promotion Incentives. Digital entrepreneurship (including agriculture) is a government priority, as outlined in the Economic Recovery and Growth Plan 2017–2020 (ERGP). The Government also adopted the Nigeria ICT Road Map 2017–2020 and the Nigeria ICT Innovation and Entrepreneurship Vision (NIIEV) released in 2018 (FAO & ITU, 2022).

### 5.3. IPRs and Digital Agriculture

IPRs are exclusive rights given to persons over the creations for a certain period (www.wto.org/index.htm). Applied to Digital agriculture, IPRs protect innovators using information and communication technology (ICT) to deliver timely information and services for the development of the agri-food sector. Regarding IPRs, there are similarities and particularities among the five AGrIDI target countries for laws and processes protecting Agri-digital innovators.

- The five AGrIDI target countries as member states of the World Trade Organization (WTO) are, abide by the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, which outlines the obligations concerning the protection of copyrights, trademarks, industrial designs, geographical indications, patents, semiconductors and undisclosed information (UN & OSAA, 2022).

- In addition, these countries are also member states of the World Intellectual Property Organization (WIPO), which offers innovators from the participating countries an online platform to easily access IPR services (www.wipo.int/services).

- At regional levels, Benin, Burkina-Faso and Côte d'Ivoire are members of the African Organization of Intellectual Properties (OAPI), which also assists Agri-digital innovators from these countries in the standard administrative procedures deriving from the uniform system of protection of industrial

property as well as from the stipulations of the international conventions (www.oapi.int/index.php/fr/services).

❖ At the country level, the Ministry of Trade and Industry and or Ministry of Justice and the representations of OAPI and WIPO provide regulations and access to IPR services. On the other hand, Agri-digital innovations from public institutions such as national Universities are primarily protected by the IPRs21 of these institutions, and the Innovators can also seek international and or regional IPRs to protect their innovations.

- **BENIN:** The National Agency of Industrial Property (ANaPI) helps inventors, innovators and academics to protect their different creations. ANAPI serves as the WIPO Directory of Technology and Innovation Support in Benin. Created by the decree N° 84-353 of 21 September 1984, the National Center for Industrial Property (CENaPI) was transferred to the National Agency for Industrial Property (ANaPI), endowed with legal personality and financial autonomy by decree N° 2010-262 of 11 June 2010 approving its statutes.
- **BURKINA FASO:** as a country member of the OAPI, the country also hosts a National Liaison Structure (NLS) of OAPI[22]. Created in 1982, this service, under the administrative authority of the Ministry in charge of the industry, helps to centralize and transmit OAPI applications for the protection of industrial property rights. It also creates awareness among the public about the IPRs and the OAPI.
- **CÔTE D'IVOIRE:** The Ivorian Intellectual Property Office [23](OIPI) is the national public institution created by Decree n° 2005 112 of 24 /02/ 2005, in charge of administering the Intellectual Property system. It also represents the African Intellectual Property Organization (OAPI) and the World Intellectual Property Organization (WIPO)
- **GHANA**: the country is a signatory of the Lusaka Agreement[24] on establishing the African Regional Intellectual Property Organization (ARIPO), which promotes IPRs among its member states. The Ghana Copyrights Office[25] also serves as a representation of the WIPO in Ghana. In 2016, the Government launched a National Intellectual Property Policy and Strategy to strengthen the legal framework for the protection, administration, and enforcement of IPR and to promote Innovation and awareness.

[21] https://www.ug.edu.gh/ttips/sites/tdtc/files/UG%20Intellectual%20Property%20Policy.pdf
[22] http://www.oapi.int/index.php/fr/oapi/organisation/structures-nationales-de-liaison
[23] https://www.oipi.ci/
[24] http://ipr.mofcom.gov.cn/hwwq_2/zn/Africa/ARIPO/file/Lusaka_Agreement.pdf
[25] https://www.copyright.gov.gh/

- **Nigeria**: The Copyrights Act, the Patents and Designs Act, and the Trademarks Act are the three main statutes[26] governing intellectual property law in Nigeria. Since January 2020, the WIPO Nigeria Office (WNO) was established in Abuja to promote awareness raising, training and capacity building in the intellectual property (IP) field and across WIPO's global services in Nigeria.

From the above, it can be stated that in the five target countries, governance of IPRs exists to some extent, including the legal and institutional framework. However, factors such as corruption, lack of enforcement, lack of skilled personnel and awareness of intellectual property rights are barriers to IPR development (Afolayan, 2022). In addition, a common trend in many African countries slows innovations among these countries compared to countries that have fully embraced e-economy, including e-agriculture, to foster growth. For example, in 2019, Africa accounted for only 0.5 per cent of the world's patent applications, compared to 66.8 per cent for Asia, 19 per cent for North America and 10.9 per cent for Europe (UN & OSAA, 2022). Hence, these countries must not only quickly work to connect the digital sector and agriculture but also to provide an environment protective of the innovators.

## 6. Towards effective interventions to support the design, scaling and adoption of digital agriculture innovations among the five target countries

### 6.1. Key lessons

The analysis of the status of digital agriculture across the five countries provides insights into each country's efforts in this sector. There are many ongoing initiatives in these countries to develop the industry. These have involved private and public interventions for deploying digital technologies in agriculture. This subsection presents the lessons learned from these countries regarding digital technologies and the enabling strategies and policies for their deployment in Agriculture.

**About agri-digital technologies, it should be highlighted that:**

- ❖ In the target countries, the knowledge production was mainly about machine learning, with a higher interest in the adoption of innovations generated through this technology to support digital agriculture;
- ❖ Compared to the rest of the world, Africa is still lagging in digital innovations in agriculture. However, technologies such as the Internet of Things (IoT), Wireless

[26] https://www.resolutionlawng.com/overview-of-the-intellectual-property-law-in-nigeria/

Sensors Networks, Artificial Intelligence, Blockchain, Unmanned Aerial Vehicle (UAV), Big data, and Geographic Information Systems (GIS) were explored.

- The studies showed that it is possible to use IoT-based solutions in agricultural production to solve many problems specific to the realities of West Africa, such as livestock theft and water pollution.
- IoT, sensor networks, and artificial intelligence can be leveraged to develop intelligent systems for monitoring crops and livestock farms and improving animal and plant health care.
- The explosion of data science and big data offers amazing tools and models for predictive analysis. The wealth of data from agriculture and its study can be harnessed to improve farming practices to increase crop yields and reduce input costs.
- Machine Learning implements very high-accuracy models to make predictions on several aspects, prevent environmental hazards, and promote precision agriculture.
- Blockchain technology makes the food supply chain more efficient by tracking all transactions.

Cases of applications of these innovations specific to the realities of West Africa were documented in the literature. However, it must be noted that in the AGriDI project target countries, despite the potential of technologies and their ability to boost the field of agriculture, agriculture remains more traditional than digital. As a result, practical agricultural solutions are not popularized and deployed in large-scale situations.

**About policy and strategies, it should be highlighted that:**

- In all countries, there is a strong engagement from public and private actors to nurture innovative solutions through different startups, platforms, projects and programs;
- There are increasing efforts from all countries to develop infrastructures and the enabling environment for digital agriculture. However, there is still a significant gap in electricity and internet access in the rural areas, which will require more engagement from all countries, especially Benin and Burkina-Faso.
- There is a need for regional harmonization to provide critical guidelines for the countries to support the development of their strategic E-agriculture plan to promote integration and experience sharing in line with different regional and international treaties.

- ❖ The five countries are members of various regional and international organizations such as WIPO, WTO, OAPI, and ARIPO, which facilitate the enforcement of IPR laws, offering platforms for innovators to protect their creation. Significant efforts should, however, be put to streamline, document, and disseminate the process of obtaining patents for the agri-digital technologies at the country level.

- ❖ The various initiatives allowed easy farmers access to agricultural inputs and markets and connected farms and consumers. These mobilizations, which varied among countries, are evolving despite the economic, political and legal challenges.

- ❖ Furthermore, the illiteracy of small-scale farmers is still a challenge in developing and adopting digital agriculture. They cannot easily use the developed technologies to increase the farms' performances.

## 6.2. Recommendations for the five countries

To be competitive and self-reliant in the global E-economy, the five countries must reposition themselves to accelerate changes in digital agriculture. There are four intervention areas (Figure 16) these countries have embraced. However, there is a need for continuous efforts to integrate these axes as interconnected parts of a road map to achieve the paradigm shift in digital agriculture transformation among the target countries: i) Policies and Regulations, ii) infrastructures (ICT and Electricity), iii) Research and Innovations for digital agriculture and iv) Intellectual Properties Rights protecting the developers of the agri-digital technologies/innovations. Therefore, these countries should endeavor to:

- ❖ Create the enabling environment for digital agriculture: Most countries have developed a national strategic plan for e-agriculture. Hence, there is a need to execute the plan and monitor the indicators of success while maintaining a window for constant improvement of the enabling political and regulatory environment. In addition, other countries like Burkina-Faso should develop a national strategic plan which should set the pillars and directives for developing key enabling factors for digital agriculture. Most importantly, the desk review revealed that though there are increasing efforts in deploying agridigital technologies and innovations, few emanate from private-public-partnership. Besides, these initiatives are pretty or less dispersed, requiring joint efforts in needs assessments and solutions to bridge the gaps.

- ❖ Develop the enabling infrastructures: The impact of digital innovations in agriculture on the livelihoods of rural people largely depends on access to electricity and the Internet. Therefore, these countries should promote

interventions and investments for increasing electric power supply and network connectivity, especially in rural areas where most agricultural labor forces are located.

- Accelerate Research and Innovations for e-agriculture: This will be achieved through strategic investments in Academia. Higher Education and Technical and Vocational Education and Training institutions are known to impact development. Therefore, strengthening the capacity of these institutions in state-of-art equipment and infrastructures will help to train more digital agriculture innovators. In addition, it may require curricula revisions connecting theoretical learning with hands-on experience from the industry. For this purpose, strengthening public-private-partnership can guarantee that the trainees are well equipped in skills and understand the market needs. This may also increase these institutions' contributions to advancing knowledge in digital agriculture and the global expertise share.
- Promote IPRs: Here, three main segments can be acted upon. First, the Government of these countries should set a clear road map for the application and deliverance of IPRs for innovations in digital agriculture. Next is to increase awareness among the public, especially the innovators and or institutions leading innovations in this area, about the availability of these services. Finally, the national authority should work to implement and enforce the laws and regulations regarding IPRs effectively.

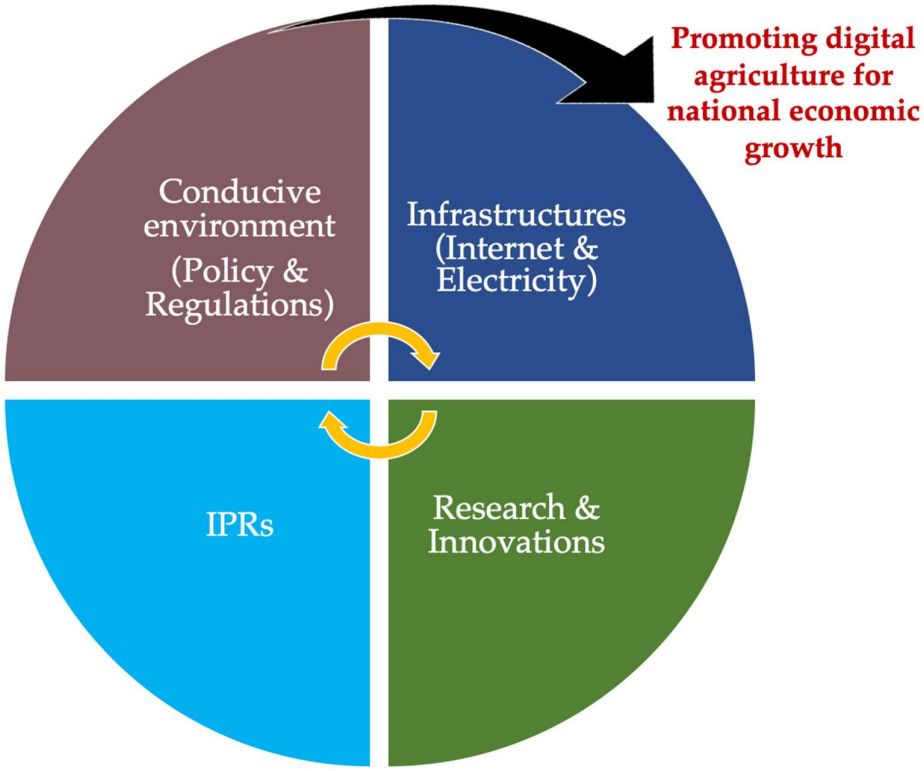



**Figure 19.** Integrated approach for promoting agri-digital innovations among the target countries

## 6.3. Recommendations for AGriDI projects

**Table 3.** Key recommendations for the successful impact of the AGriDI Projects

| Category | Projects | Recommendations |
|---|---|---|
| Co-development & adaptation of digital solutions | AGriCef, A digital solution for a more effective and efficient agro-ecological management of the Fall armyworm ("Chenille légionnaire d'automne"CLA) in Northern Benin (CLA) (DigiCLA) | -Propose field monitoring and early pest attack detection systems through AI and sensor networks.<br>-As solution-based sensor networks and the Internet of Things are the leading documented technologies in the scientific literature, it will be helpful to explore the application of data science and AI to predict the development of armyworms. |
| | Digital Soil Mapping for Optimal Agricultural Yield and Sustainable Soil Biodiversity in Southwest Nigeria Using Artificial Intelligence (FUNAAB-SMARTSOIL) | -Consider the seasonal differences in the country in the implementation of the project.<br>-Use machine learning algorithms such as random forest, gradient boosting and cubist to perform data analysis.<br>-Use multi sources like radar sensors, optics sensors and satellites to collect multi-temporal data about soil moisture, soil temperature, air temperature and soil composites.<br>-Exploit IoT technology and IA in conjunction to propose soil cartography.<br>-Propose precision irrigation and fertigation systems to control water quantity and nutrients of each plant |

| | | |
|---|---|---|
| | Precision Pest and Disease Management System based on Multidimensional Big Data (PPeDMaS) | -Develop a multi-sensor network system to collect environmental data on vegetable production sites.<br>-Install solar stations in the vegetable garden to provide wireless sensors with AC power.<br>-Develop and train deep-learning convolutional neural networks (DL-CNNs) to distinguish, identify, and geo-locate pests and diseases using data from multiple cameras.<br>-Develop a vegetable pest warning system. |
| | Solar-Powered Refrigerated Containers for Social Impact (COOL-LION) | -IoT technology can be used to make a more significant impact |
| Digital innovations for establishing market linkages | Boosting rice and maize supply chains through innovative e-market and financial services to smallholder farmers in Benin (BoMeF) | -Blockchain can help to track the entire supply chain and market. |
| | Improving Women's opportunities to access microfinance for solar-powered agro-processing equipment (MarketMap) | -Propose an intelligent energy management system: smart grid. |
| | Digital Tools to Drive Market Access and Manage Ag-Value Chains (DigiMakt) | -Blockchain technology can bring innovation in this field. |
| | Scaling AgroCenta Platform and Adoption for Effective Market Linkages in Ghana (SAPA) | -Clearly define the stakeholders' roles, responsibilities and benefits and monitor the success indicators. |
| Policies for digital innovation | Strengthening the political and regulatory environment for the development and scaling up of digital innovations in the agricultural sector in Benin (REPINAB) | -Promote inclusion and full participation of actors from all e-agriculture-related sectors in the decision-making process about the key priorities.<br>-Organize round table discussions among stakeholders for assessing the indicators of successful implementation of the national e-agriculture strategic plan.<br>-Streamline and raise awareness about obtaining IPRs for e-agriculture innovations at the national level. |
| | Enhancing farmers' uptake of digital technologies through empirical research, innovation and policy intervention (EFUDTRIP) | -Ensure that the needs of the small-scale farmers are mapped out and addressed.<br>-Promote inclusion and gender-balanced interventions with high participation of women and youths in the research process. |

## 7. Conclusion and perspectives

This study was conducted to assess the state of digital agriculture in west-Africa, analyse existing efforts in developing the enabling environment and innovations, and formulate recommendations based on the identified gaps for the effective transformation of the sector. The report considers five countries: Benin, Ghana, Burkina-Faso, Nigeria, and Côte d'Ivoire. It provides a bibliometric analysis and an overview of these five countries' digital technologies in agriculture. In addition, it describes the digital technologies and their adoption status as well as an analysis of

the stakeholders and policies in the countries concerned. The study showed that the digital technologies used in agriculture include blockchain, the Internet of Things, Big Data, machine learning/deep learning methods, etc. Among the five countries considered in this work, Nigeria is the most advanced in adopting these digital technologies in agriculture.

On the other hand, Benin and Burkina Faso are ranked as the countries with minor use of digital technologies. Each country's digital ecosystem evolves with new policies, initiatives, innovations, and stakeholders. The coordination of efforts and actions will boost co-creation and fully harness the potential of digital technology in transforming agri-food systems in the target countries.

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## ANNEXE: Logical framework baselines

| | *Results Level* | *Indicator* | *Definition* | *Baseline (value & ref. year)* | *Target (value & ref. year)* | *Data Sources* | *Frequency* | *Reporting* |
|---|---|---|---|---|---|---|---|---|
| ***Impact (Overall objective)*** | Conducive environment for agri-based digital innovations, especially for women and youth farmers, and accelerating inclusive green growth in the targeted countries of West Africa | 1. Labour force participation rate for women and youths (by country) | Labour force participation rate is the percentage of the population that is either working or actively looking for work. The labor force participation rate is calculated as: **(Labor Force / Civilian Noninstitutional Population) x 100** | 75.7% (2020) | 76% (2024) | International Labour Organization (ILO) | Start (baseline) and end (end line) | Project outcome and impact evaluation |
| | | 2. Percentage change in income for small-scale food producers (by country) | Average income of the participating farmers at the end of each year divided by the average income of the participating farmers at the end on the previous year, multiplied by 100. | 0% (2020) | 10% [27] (2024) | National agricultural survey reports | Start (baseline) and end (end line) | Project outcome and impact evaluation |

[27] We use: Siaw A, Jiang Y, Twumasi MA, Agbenyo W. The Impact of Internet Use on Income: The Case of Rural Ghana. *Sustainability*. 2020; 12(8):3255. https://doi.org/10.3390/su12083255. In their paper they estimate that internet increased household income of households that did not engage in off-farm activities by about 25%. We set a lower figure of 10% project activities in the target sites are limited.

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| | | 3. $CO_2$ emission per unit of value added avoided or reduced (t $CO_2$/USD) (by country) | This is the ratio of the Green House Gas emissions (GHG)/Gross Domestic Product (GDP) ratio of a country in a particular year compared to the same ratio in a proceeding year | -Benin 0.51<br>-Burkina Faso 0.28<br>-Cote d'Ivoire 0.22<br>-Ghana 0.31<br>-Nigeria 0.28<br>(2020) | TBD during baseline survey (Not available) | https://fr.countryeconomy.com/ | Start (baseline) and end (end line) | Project outcome and impact evaluation |
| ***Outcome(s) (Specifico*** | **Outcome 1:** Increased uptake of agri-based digital technologies by farmers' cooperatives and SMEs | 1.1 Number of farmers cooperatives reporting use of the agri-based digital technologies produced / promoted through the Intervention (by country) | The number of farmers' cooperatives identified as using agri-based digital technologies produced directly through the actions of the intervention or through partners/grantees | 0<br>(2020) | 12<br>(2024) | Grantees reports; Intervention progress reports | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |

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| *bjective(s))* | | 1.2 Number of SMEs reporting use of the agri-based digital technologies produced/promoted through the Intervention (by country) | The number of SMEs identified as suing agri-based digital technologies directly made by the interventions or through its partners | 0 (2020) | 12 per country (2024) | Grantees report; Intervention progress reports | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | | 1.3 Number of grantees able to mobilize additional financing for the development and promotion of agri-based digital techniques for usage by farmers' cooperatives and SMEs | The intervention grantees were identified as having secured additional funding to support the development and promotion of agri-based digital tools for use by farmers' cooperatives and SMEs | 0 (2020) | 3 per country (2024) | Grantees report; Intervention progress reports | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | **Outcome 2:** Strengthened collaboration between research communities, industry, and policy actors in digital innovations | 2.1 Number of active networking platforms involving research institutes, industry and | Number of networks platforms found to be active with research institutes, industry and policy makers actively registered and | 0 (2020) | 1 per country (2024) | Reports from networking platforms | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |

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| | | policymakers established (by country) | participating on the platforms | | | | | |
| | | 2.2 Number of actors registered in the active networking platforms facilitated by the Intervention (by country) | Number of actors actively reported on the networking platforms facilitated by the intervention. This should focus on those actors who are identified as active | 0 (2020) | 500 per country (2024) | Reports from networking platforms | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | **Outcome 3:** Improved knowledge on policymaking facilitating scaling agri-business digital innovations | 3.1 Number of policy documents (e.g., draft laws, strategies, and plans) facilitating scaling agri-business digital innovations developed (because of the Intervention's assistance) (by country) | This is a count of the number of policy documents (e.g. draft laws, strategies and plans) aimed at facilitating the scaling of agri-business digital innovations developed with the facilitation of the intervention. This should only include published documents | 0 (2020) | 4 per country (2024) | Official Journals; Other Government reports; Intervention evaluation reports | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | | 3.2 Number of Policies / Regulations / Administrative | A count of the number of Policies, Regulations/ Administrative procedures adopted/implemented with | 0 (2020) | 1 per country (2024) | Official Journals; Other Government reports; | Semi-annual | Annual project reports, end-line survey report, |

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| | | procedures adopted / implemented (because of the Intervention's assistance) (by country and stage of operationalization) | facilitation of the intervention. The reporting should clearly clarify the stage of operationalization of the policies | | | Intervention evaluation reports | | Quarterly reports |
| | **Output 1.1:** Farmer cooperatives and SMEs provided with innovative digital solutions adapted to their needs | 1.1.1 Number of innovative digital solutions provided by grantees that are adapted to the needs of farmers' cooperatives and SMEs (by country) | A count of the digital solutions adapted by grantees to the needs of farmers' cooperatives and SMEs provided by grantees. Adapted solutions should clearly have a defined process of being adapted for instance, a report | 0 (2020) | 8 per country (2024) | Intervention evaluation reports; Grantees reports | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |
| | | 1.1.2 Number of innovative digital solutions disseminated for use by farmers cooperatives and SMEs (by country) | A count of innovative digital solutions disseminated for use by farmers' cooperatives and SMEs | 0 (2020) | 8 per country (2024) | Intervention evaluation reports; Grantees reports | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |

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| | **Output 1.2:** Enhanced capacities of grantees (SMEs, leaders of farmers cooperatives and policy actors, especially women and youth) in using digital solutions for agri-business development | 1.2.1 Number of grantees trained in agri-based digital tools (by country, sex and age) | A count of the number of grantees trained in agri-based digital tools | 0 (2020) | 60 per country; 50% women, 40% < 35 (2024) | Intervention progress and evaluation reports | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | | 1.2.2 Percentage of trained grantees who report increased knowledge in agri-based digital tools (by country, sex and age) | This is the number of trained grantees reporting increased knowledge in agri-based digital tools divided by the total number of grantees trained | 0 (2020) | 60 per country; 50% women, 40% < 35 (2024) | Intervention progress and evaluation reports | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | **Output 2.1:** Functional multi-stakeholder networks established | 2.1.1 Number of multistakeholder networks among research communities, industry and policy actors established (by country/sub-region) | Number of functional multistakeholder networks involving research communities, industry and policy actors established with the support of the intervention | 0 (2020) | 12 per country (2023) | Reports of multi-stakeholder fora/platforms | Semi-annual | Annual project reports, end-line survey reports, Quarterly reports |
| | | 2.1.2 Number of multistakeholder networks | Number of multistakeholder/networks meetings/conferences | 0 (2020) | 12 per country (2024) | Reports of multi-stakeholder fora/platforms | Semi-annual | Annual project reports, end-line survey reports, |

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| | | meetings / conferences organized (by country/sub-region) | organized with support of the interventions | | | | | Quarterly reports |
| | **Output 2.2:** Improved awareness of stakeholders in digital Innovation on Inclusive Green Economy (IGE) issues | 2.2.1 Number of media hits (including social media) (by country) | Total number of media hits, including social media hits, for intervention outputs reported/captured | 0 (2020) | 60,000 per country (2024) | Intervention progress and evaluation reports | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |
| | | 2.2.2 Number of knowledge and communication materials developed promoting digital Innovation on Inclusive Green Economy (IGE) issues (by country and type of product) | Number of knowledge and communication materials developed with the support of the intervention to promote digital Innovation on Inclusive Green Economy (IGE) issues | 0 (2020) | 20 per country (2024) | Intervention progress and evaluation reports; Press articles | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |
| | **Output 3.1:** Improved awareness of policymakers on the importance of agri-based digital innovations | 3.1.1 Number of policy briefs produced by grantees (by country) | Number of policy briefs produced by grantees and supported by the interventions | 0 (2020) | 4 per country (2024) | Intervention progress and evaluation reports; Press articles | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |

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| | | 3.1.2 Number of policy-related events / consultative meetings held by grantees with national government entities (by country) | Number of policy related events/consultative meetings held by grantees with national government entities and supported by the intervention | 0 (2020) | 4 per country (2024) | Intervention progress and evaluation reports; Press articles | Semi-annual | Annual project reports, end-line survey report, Quarterly reports |