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DIGITAL AND INFORMATION COMMUNICATION TECHNOLOGY DRIVEN INNOVATIONS FOR ADOPTION FOR THE DEVELOPMENT OF NIGERIAN AGRICULTURE.

By

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Abstract

This review highlights some digital and ICT driven innovations that can adopted to help develop the Nigerian Agriculture The global population is projected to reach 9 billion people by 2050, with nearly 2 billion of those people living in Africa. Global population growth, particularly in Africa, looks set to boom before there is a food system in place that can support all people at all times.. The idea of Africa feeding itself is not farfetched though; Africa has about 65% of the world's uncultivated, farmable land; Africa is endowed with a wide diversity of agro-ecological zones, such as heavy rain-forest vegetation and dry-arid vegetation; agriculture provides around 60% of all jobs on the continent; and Africa uses only 2% of its renewable water resources, compared to 5% globally. By 2025, an estimated 330 million young Africans will enter the labour market. Hence, there is a need to match youth unemployment with the enormous potential of African agriculture. Young people picture the druggery of farming and perceive agriculture as low income employment sector in recent years though. Digitalization and agriculture technologies have enhanced the way that food is produced. ICT-enabled agriculture is gradually changing the mindset of young people and creating young entrepreneurs who are willing to take risks and invest in agriculture Literature materials on digital and ICT innovations that can be adopted were assembled from Journals, Conference proceedings, books , magazines , bulletins etc, they were there after reviewed and discussed. The pest risk management system, livestock vaccine digital delivery service in Ghana, climate risk management system, CTA supported climate-livestock project in Kenya, Caribbean soilless solution to boost smart production, , development of crop robotics in Samoa etc The review also listed strategies to upscale agriculture in Nigeria and Africa. The integration of digital technologies and ICT with agricultural extension is essential for modern agricultural development. These concepts work synergistically to address challenges such as food insecurity, climate change, and resource scarcity. By leveraging these tools and approaches, stakeholders can create a more sustainable and resilient agricultural sector., The above innovations are worth while and are capable of boosting agricultural production in Nigeria, if adopted, thus helping to attain food security. As the world continues to face unprecedented challenges, the role of these interconnected concepts in driving agricultural transformation cannot be overstated. Policymakers, researchers, and practitioners must work together to promote the adoption of innovative technologies, The innovations discussed above are recommended for adoption by policy makers and farmers for the development of Nigerian Agriculture. Dissemination mechanisms should be put in place to ensure that these innovations /technologies reaches the nooks and crannies of Nigeria

Keywords: Agricultural, Adoption, Digital, Innovation, Information Communication Technology, Nigeria

INTRODUCTION

The global population is projected to reach 9 billion people by 2050, with nearly 2 billion of those people living in Africa. Global population growth, particularly in Africa, looks set to

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boom before there is a food system in place that can support all people at all times. (CTA,2019)

The idea of Africa feeding itself is not farfetched though; Africa has about 65% of the world's uncultivated, farmable land; Africa is endowed with a wide diversity of agro-ecological zones, such as heavy rain-forest vegetation and dry-arid vegetation; agriculture provides around 60% of all jobs on the continent; and Africa uses only 2% of its renewable water resources, compared to 5% globally. The issue, however, is that smallholder farmers aged 60 years and above account for over 80% of agricultural food production in Africa. This is despite the fact that half of Africa's population is aged under 25 years (Spore Magazine, 2018)

By 2025, an estimated 330 million young Africans will enter the labour market. Hence, there is a need to match youth unemployment with the enormous potential of African agriculture. Young people picture the druggery of farming and perceive agriculture as low income employment sector in recent years though. Digitalization and agriculture technologies have enhanced the way that food is produced. ICT-enabled agriculture is gradually changing the mindset of young people and creating young entrepreneurs who are willing to take risks and invest in agriculture.

Digital solutions and platform, such as smart- mobile applications, remote sensing technology, big data, digital soil maps, social media, blockchain, drones, precision technology and cloud based computing, have the tendency to not only increase food production and market efficiency, but also accelerate youth involvement in agriculture. Over the past years, private sector companies and donor agencies have become increasingly aware of the role that digital agriculture can play in driving agriculture,(FAO, 2017) Mobile applications and low tech solutions have been developed by different stakeholders, including young entrepreneurs, to tackle issues related to production, input supply, finance, processing, logistics, and marketing. The key question is whether digital agriculture is enough to drive growth and ensure sustained youth involvement in agriculture.

There is a popular assertion that on average, young people are smart, energetic, innovative and capable of integrating technology into their activities. These attributes are complementary to what digital agriculture can offer, enabling young people to transform agriculture in Africa from the palm of their hand. Across agricultural value chains, digital agriculture has proven to be a timely wat to attract youth into agriculture, but the rubber still needs to link youth involved in digital agriculture with substantial financial inclusion, investment support from both the private and public sectors, and tailored agricultural training.

Dr Akinwunmi Adesina, president of the African Development Bank, emphasizes the potential of digital agricultural technology, such as digitally enables agriculture, precision farming , hydroponics, robotics, and artificial intelligence, is expanding globally. The future farmers that are not physically engaged in agriculture. Theses farmers will take agriculture to the next level, a level shaped by innovation. (Spore Masgazine,2019)

According to Dr Debisi Araba " prosperity approach needs to overtake a poverty reduction approach, to encourage young people into making a career in agribusiness. The future of Africa is not seeing more youth on the farm, but more youth at the top of the value chain pyramid where digital agriculture creates multiple entry points for young people looking to get involved in agribusiness The integration of digital technology and ICT into Agriculture is essential for modern agricultural development.(Kassie *et al*, 2015) These concepts work synergistically to address challenges such as food insecurity, climate change, and resource scarcity. By leveraging these tools and approaches, stakeholders can create a more sustainable and resilient agricultural sector. As the world continues to face unprecedented challenges, the role of these interconnected concepts in driving agricultural transformation cannot be overstated. Policymakers, researchers, and practitioners must work together to promote the adoption of innovative technologies, strengthen extension services, and harness the power of ICT to ensure a food-secure future for all. (Kassie and Mehar, 2016).

This review highlights some digital and ICT driven innovations that can be adopted to help develop the Nigerian Agriculture

Review of Concepts

Innovation

Innovation in agriculture refers to the development and application of new ideas, technologies, and practices to solve agricultural challenges. It encompasses technological advancements, such as improved seed varieties, as well as social innovations, such as farmer cooperatives and participatory approaches to agricultural research. Innovation is not limited to high-tech solutions but also includes low-cost, context-specific adaptations that address local challenges.

Innovation drives agricultural development by addressing challenges such as climate change, pest outbreaks, and resource scarcity. For instance, the adoption of drought-resistant maize varieties in East Africa has significantly improved food security in drought-prone regions (Kassie *et al.*, 2015). These varieties, developed through collaborative research between scientists and farmers, are tailored to withstand harsh climatic conditions while maintaining high yields. Additionally, innovations in farm management practices, such as integrated pest management (IPM), have reduced relian9ce on chemical pesticides, promoting environmental sustainability and reducing production costs for farmers.

Technology

Agricultural technology includes tools, machinery, and techniques used to enhance farming efficiency and productivity. Examples include precision farming equipment, irrigation systems, and biotechnology. Technological advancements have revolutionized agriculture by enabling

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farmers to monitor and manage their operations with greater precision and efficiency.

Technology adoption has transformed agriculture by enabling farmers to produce more with fewer resources. For example, the use of drip irrigation systems in India has reduced water usage while increasing crop yields (Narayanamoorthy, 2005). This technology is particularly beneficial in arid and semi-arid regions where water scarcity is a major constraint. Similarly, the adoption of mechanized farming equipment, such as tractors and harvesters, has reduced labor requirements and increased p9roductivity, particularly in large-scale farming systems. Biotechnology, including genetically modified crops, has also played a significant role in enhancing crop resilience and nutritional value, contributing to global food security.

Digital

Digital agriculture involves the use of digital tools and platforms to collect, analyze, and share agricultural data. This includes mobile apps, satellite imagery, and digital marketplaces. Digital agriculture leverages data-driven insights to optimize farming practices, improve decision-making, and enhance market access for farmers.

Digital tools empower farmers with real-time information on weather, market prices, and best practices. For example, the *e-Choupal* initiative in India provides farmers with digital access to market information, enabling them to negotiate better prices for their produce (Mittal & Mehar, 2016). By connecting farmers directly to buyers, this platform eliminates intermediaries, ensuring fairer prices and9 higher incomes for farmers. Additionally, digital platforms such as weather forecasting apps a9nd soil health monitoring tools enable farmers to make informed decisions, reducing risks and i9mproving productivity. The integration of digital technologies into agriculture also facilitates trace9ability and transparency in supply chains, enhancing consumer trust and marketability of agric9ultural products.

Adoption

Adoption refers to the process by which farmers accept and implement new technologies or practices. It is 9influenced by factors such as affordability, accessibility, and perceived benefits. Adoption is a cr9itical step in the innovation diffusion process, as it determines the extent to which new technologies are integrated into farming systems.

The adoption of improved technologies is critical for achieving sustainable agricultural development. For instance, the widespread adoption of hybrid rice varieties in China has significantly increased rice production, contributing to food security (Huang *et al.*, 2002). However, adoption rates vary widely depending on socio-economic factors, such as education levels, access to credit, and extension services. To promote adoption, it is essential to address barriers such as high initial costs, lack of awareness, and resistance to change. Participatory approaches, where9 farmers are involved in the development and testing of new technologies, have proven effective in increasing adoption rates by ensuring that innovations are tailored to local needs and conditions. Most research and development workers often ignored the significance of indigenous knowledge system as they consider it to be primitive, Backward, Cultural bound and irrational. However, recent research findings indicate that some of the traditional farming practice once regarded as primitive and or misguided are being recognized and accepted as sophistical and appropriate (Altieri, 1998; Gliesman, 1980). There is no doubt that researchers and extension workers in their desire to improve the productivity and standard of living of their clienteles at times treat the local population's indigenous knowledge with disdain, without time to listen to them. In this way often miss the target, in light of this Olawoye (2002) asserts that in our concentration upon the problems of the local population we often overlook the positive aspect within rural areas that can contribute to solutions to these problems

ICT (Information and Communication Technology)

ICT encompasses technologies used to communicate, store, and process information. In agriculture, ICT includes mobile phones, internet platforms, and geographic information systems (GIS). ICT has become a powerful tool for bridging information gaps and connecting farmers to markets, services, and knowledge resources.

ICT facilitates the dissemin9ation of agricultural knowledge and connects farmers to markets and services. For example, mobi9le-based advisory services like *Esoko* in Ghana provide farmers with timely information on w9eather and market prices, improving decision-making (Aker, 2011). These services are particularl9y valuable in remote areas where access to traditional extension services is limited. Additional9ly, ICT platforms such as GIS and remote sensing technologies enable precision agriculture by 9providing detailed insights into soil conditions, crop health, and resource availability. By levera9ging ICT, farmers can optimize input use, reduce waste, and increase profitability, contributing9 to sustainable agricultural development.

REVIEW OF CASE STUDIES

As reported by (CTA 2019) Abubakar karim, a 23 year old man from Cote d'Ivoire, has made it his mission to put an end to agricultural losses as a result of poor crop management "we can not carry out farming the same way our grandparent did, using the hoe and machetes that people have been using for 300 years, "he says. Karim's field mapping company, investiv's, launched its first drone service in May 2017, the firm's six drones each equipped with multi-spectical imaging camera and operated by internally trained pilots. Produce agricultural land use maps to pinpoint area of crops disease, poor soil fertility or under-hydration. The company then analyses the data so that farmers can take appropriate action, for instance by fine tuning fertilizer and disease control product dosages or using water and inputs more efficiently. Customers can also log into investiv's Land management platform to view the latest data on their farms. " to date, we've managed more than 5,000 ha of farmland. "says Karim.

Ag-tech's Potential to Boost Women's Empowerment (The ag-Tech Revolution)

There's no question that technology is revolutionary farming. Agriculture is now an infinitely smarter ecosystem where

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sensors, robotic, 3D printing, Cloud Based computing and artificial intelligence are becoming normalized. Drones and connected machines are becoming more affordable, giving rise to smart devices for farming suppliers and services providers, allowing the exchange of huge amount of data, farming is also becoming more precise. And, while there are some aspects that digitalization cannot change – bad weather conditions, crop and animal diseases, and commodity market fluctuations – big data and predictive analytics enable real-time migration strategies to manage these conditions.

But technological development does not exist in isolation, And, within rural communities, digitalization is not necessarily advancing agribusiness at the pace it should. If anything, it is still in its infancy. Emerging nations often have the minimum scientific capacity to implement digital solution that could solve everyday agribusiness problems.

"It would be a half – baked truth to say the technology has been rolled out fully across Africa, specifically in the agricultural barriers with women. "Explains Fatima Alimohamed, CEO of African Brand Warrior, A Kenyan-based marketing company well known for their rebranding work across Africa. "She said, whatever technology has brought significant improvements, with women not only having access to information at their fingertips, but also enabling them to be part of the [agricultural] value chain, right down to payment linked to farm produce," she says.

According to CTA (2019) Farmers in Nigeria are Accessing soil data in real-time to better manage their crop growth and access financing that was previously out of reach. Zenvus, a precision farming company, has created electronic sensors with in-built GPS, which are placed in the soil to measure pH, nutrient content, Moisture level and temperature. The data collected from different farms is Aggregated and analyzed according to location, and the appropriate advice is then provided to farmers via a "Smart Farm" web and mobile app. Using this data, farmers are able for instance to apply the correct fertilizer and optimally irrigate their farms, leading to enhanced farm operations, reduced input waste, and improved productivity.

Farmers can also collect on farm images of their crops using the Zenus 'Yield' – a hyper-Spectral imaging camera that monitor Farms vegetation to detect potential problems, including data-driven farming systems and processes across a nexus of modern agriculture, including credit, irrigation, planting and harvesting.' Says professor Ndubuisi Ekekwe, founder of Zenus.

Financial service providers can also access the farm data collected- if previously agreed with the -farmers – to help with decision regarding the provision of insurance, loans and / or investment. Using the GPS software within the sensors, the technology also gathers data regarding farm boundaries and land area. Investors can review this data along with information on the type of crop grown- to work out potential yields and profit when considering investment and lenders pay a subscription fee to view the information through a separate platform called 'Zcapital'

Another Zenus service, 'Zlnsure', enables farmers to apply for insurance by uploading data about their farm, which is also independently verified by the company. Not only do insurers, which helps reduce premiums. " Zenus has used technology to remove information asymmetry, making it possible for farmers to share data with lenders and insurers, creating a specialist system, which has improved their capacities to access credit. Enabling lenders to know what they are funding gives them higher confidence to provide credit,." Explains Ekekwe.

The SmartFarm Technology, Which cost €175 to €525 depending on the size and scope of the sensors, as well as the data transmission source (Cellular, Wifi or satellite), Also provides services for different subscribers. Fertiliser manufacturars, for instance, can use the data collected to determine what fertilisers to produce to meet the soil nutrient requirement of farmers in specific regions. The data can also be used by government or development organizations looking to keep track of farms they have supported in a particular Location.

Following its launch in 2014, SmartFarm was first deployed in the eastern part of Nigeria. The technology has since been scaled out 500,000 farming entities and used nationwide in Nigeria, as well as in Botswana, Ghana and Rwanda. "I was initially skeptical [of the Zenus sensor], but later decided to try it. I got a huge crop yield and harvested so much. The good things is that the device is so easy to use." Says Cyracus Obiah, a farmer from Imo state in Nigeria.

Livestock Vaccines: Digital Delivery Service

Women livestock farmers in rural Ghana are receiving veterinary services, delivered to their door at the tip of their fingers when they register with Cowtribes App

In the pastoral northern Regions of Ghana, as in many African countries, women bear the household. As livestock farming is the primary source of income, this includes rearing farm goats, sheep, and poultry. However, the high prevalence of disease often leads to the death of their animals. To help farmers fight livestock disease. Cowtribe has developed a digital on demand and subscription based services which delivers livestock vaccine to rural farmers.

Leveraging Technology

Cowtribes Lamisi project aims to ensure that men and women have equal access to veterinary services using cloud-based logistics management system, which enable delivery of vaccine services to farmers when and where they are needed. The system also allows farmers to track the health of each animal, and reminds them when their animals need veterinary services.

'by leveraging technology to digitize data, we are able to see areas where services are lagging and we make sure service reach the farmers in a very affordable and convenient manner, says Alima Bawah, co-founder of Cowtribe, which she helped to establish in 2016, with farmers subscribing to the service by mobile phone, Cowtribe can collect relevant information

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about farmers and his/her animals in order to better understand their needs.

Alima Bawah is excited to be implementing innovative livestock solution to benefit women's livelihoods. As a girl, growing up with her grand-mother in Ghana's northern Region, Alima never encountered a veterinarian. The house hold Poultry often died from Newcastle disease because the family could not access vaccines. "Finding this kind of solution for other rural folks that are living like myself and my grandmother is something that gives me inner satisfaction." She enthuses.

A Tailor-made Solution

Cowtribe selects target communities based on population size, livestock population, main income source and other relevant information. A concept selling meeting is organized by field agents to mobilize interest within the community and inform farmers about the value of vaccine as, well as how Cowtribes helps farmers to access veterinary services. Those with livestock, who are convinced by the value of the platform, are registered and signed up to Cowtribe for an annual subscription fee of €4.50.

Although mobile phones are prevalent in Ghana rural area, internet connectivity is limited. However, Cowtribes system is tailor-made to ensure that internet access is not a limitation. "we have built our platform to be offline, so the agents that are using our app in the field to register the farmers do not need to have internet before they use the platform.' Alima explained.

Orders for Vaccines within a community are aggregated to enable delivery in bulk – some vaccines are given out for free and others at subsidized prices. Registered women also receive voice messages in their local languages via their mobile phone, which tell them the availability of vaccine, as well as offering advice on best farm practice and livestock management.

Economic and Social Value

The access to vaccines provided by cowtribes has helped to reduce high stock mortality rates and increase farmers' incomes. Since subscribing to Cowtribes, Latif Yapaga, a 34-year-old mother of four from the Gbugli community in Kumbungu district, has increased her poultry birds from seven to 21 without being affected by the out-break of diseases. The income she has generated has enabled Yapaga to buy school uniform for her children. "Previously, our animals would die unexpectedly, but now we have vaccine to keep them healthy. We are on the path of multiplying our livestock and hopefully my family will have a better furture." She says.

"our focus is not just in the commercial value but the social impacts that we are making." States Alima. To promote women's economic empowerment, Cowtribe works with groups of women to ease the process of sharing information and also help them to support each other. Each woman in the group is given two birds to produce 20 and then pass on two to the next woman in a revolving scheme.

Future Opportunities

Since its inception, Cowtribe has expanded its service to 30,000 Farmers in 230 communities in the Brong Ahafp, Nothern Upper East and Upper West regions of Ghana, and around 200 Vets have been trained to provide support service. By the end of 2019, the target is to reach 100,000 farmers from 10 communities in each of Ghana 10 regions . women constitute at least 60% of Cowtribe's target.

In march 2019, a new app called Benefy was launched to enable third party applicant to buy vaccines through remittance for delivery to a beneficiary at location. A son living in the greater region purchase a vaccine for his mother in the northern Region. "we are looking at a future where every farmer has access to animal vaccine…. Where there are no more disease that are killing livestock's that would have otherwise helped to pay school fees." Explains Alima.

In the future, Cowtribes also hopes to link livestock's farmers to markets to help sell their product. " Now they have access to vaccine at their convenience and there is no more mortality amongst their flock, as a result of disease….. farmers are able to sell their surplus livestock to meet their needs." Says Alima. Cow tribes is building partnership and receiving attention at the national and international levels to achieve these ambitions.

The social enterprise was selected as one of the 25 finalist in CTA's Pitch AgriHack 2016 start-up competition, which provided business training and mentorship, as well as the opportunity to pitch their digital solution to potential investors. Cowtribes has also gained visibility through wining the british council Social Innovation Challenge in December 2016 and coming second in the Gender in Agribussiness Investment for Africa Agtech west Africa challenge in April 2017.

DATA4Ag Puttin

Mobile App Automates Agricultural Contracting

A credit rating app is enabling Zimbabwean small-scale farmers to build up credit profile, helping them to compete in the market for finance.

In Zimbabwe, over 3,000 small-scale farmers are benefiting from a grower management' system, which is improving their access to agricultural inputs and finance. Developed in 2015, Agro Axess is a mobile app that store the farm information of smallholders looking to work with potential contractors. The data, such as farm size, the type of produce grown and yield levels, is added to the app by field workers associated with agricultural contracting companies. Integrated into the app is credit rating system, which records information regarding a farmers access to input and/ or credit from the contractors, and their subsequent harvest repayments. This information is compiled over time to create credit profile, which can then be used by financial service providers and other contractors to track a farmers activities and their creditworthiness.

The app is the invention of Zimbabwe's largest agricultural risk management company, Expert decision system (XDS). " we have contractors in the country who lent to small-scale farmers in the form of cash and input. However, there was

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no proper system that was used to track farmers. Looking at how productive they are and how well they repay their loans. We decided in credit data," says Oleen Manponga, an XDS director.

The technology can warn Contractors of any doubles-dipping activities- when a farmer get input from two separate contractors for the same piece of land – or side-making activities. The application does this by flagging or blacklisting a farmer. Once registered, the app runs a credit check on the farmers to see if they have existing debt with other contractors, retailers or financing institution According to farayi Dyirakumunda, another director at XDS, there has been high demand for and use of the technology among tobacco and cotton contractors, as well as microfinance institutions.(CTA, 2019)

Farmers registered with the app have improved their debt profile, with default payment rate declining from 17% in 2016 to 9% during the 2017-2018 farming season. This is most likely due to applications repayment monitoring, which warns credit providers if the farmers do not fulfill their obligations. "what has changed from when we started is that farmers have more access to credit balance, at XDS, we now have more information on the farmer," reiterates Maponga.

Pest Control

Data-Science anticipates risk

To mitigate the devastating impact of pest, esteemed to cause around 40% of crop losses worldwide, researchers in the UK have developed a service that uses satellite and earth observation data to forecast the risk of pest outbreak. The pest Risk information service (PRISE) feeds information related to temperature, weather forecast and plant-pest lifecycles into a computer model that predict when an outbreak is likely. Farmers using the service receive an alert to their mobile phones when there is high risk of an outbreak, enabling them implement appropriate precautions, PRISE is currently being used in Kenya, Ghana and Zambia, where it is hoped to improves yields and increase farm incomes by up to 20% .

According to John Agboola digitalization is a timely magnet for youth involvement in agriculture.

Bridging the gap between farmers and investors

A digital platform, which is connecting farmers in rural areas with young professionals in cities Aims to increase food production in Nigeria, while also promoting youth participation in agriculture. Through the digital start-up, Farm crowdy, smallholders are linked with investors who are willing to sponsor agricultural activities, which enable farmers to improve their production and expand their farming operations. The company's Mobile app sends a notification to potential investors when farms are open for sponsorship, and investors then select the smallholdings they are interested in supporting, at the end of the farm cycle, farmers, sponsors and Farm crowdy share the profit from the harvest sales. (CTA, 2018)

In Nigeria, convincing commercial banks to invest in small agribusiness is challenging, with lenders usually shying away from farming because of the associated risk. Farm crowdy aims to address this issue by pooling funds from numerous investors and spreading the risk among a large population of middle-class Nigerians, most of whom invest about ₦100,000 (€24) per farming cycle. investors receive between 6% and 25% as returns on the funds they provide- usually within a year- in addition to the capital they invest, and are able to monitor their investment from their homes or offices through the text, picture and video update they receive via app.

"I have always wanted to invest in agriculture without getting my hands dirty and Farm crwody has given me the opportunity to do so," says Julcit Bali, a sponsor based in Nigeria's Capital, Abuja. Another sponsor, Chigozie Egbunefu, based in Port Harcourt in the south of Nigeria says, "[farm crowdy] is unique because of the coordination of its activities and regular updates to sponsors. It took away the burden of supervision and monitoring and I would certainly recommend Farm crowdy to others."

Farm crowdy provides information on the availability of farm produce – usually cassava, soya beans, and rice through their websites and app, which helps farmers from other platforms and turns a complex problem into a digital marketplace," says Farm crowdy CEO, Onyeka Akumah. The company is also connected with agri-based companies that use raw agricultural materials in their production processes, creating a ready market for farmers, in addition, Farm crowdy uses the sponsorship funds to provide agricultural inputs and services, such as seeds, fertilizers and farm equipment to ensure good yields, as well as to pay for insurance cover both the farmers and sponsors in the event of a poor harvest.

In less than 2 years over 7000 farmers have benefited from 13,683 sponsorship and the platform has amassed over 64,000 follower. "Before Farm crowdy, I used to cultivate one or two plots, but now I have expanded to cultivate 16 to 16 plots, which is about 1 ha of land," says Blessing Jacob, a 24year old cassava farmer from Akwa Ibom state. Through Farm crowdy's technical support and agricultural advice which is provided by the company's field agents, Jacob has also been able to boost her yields of cassava, which are now bigger and healthier," she says. Victor Akpan, another young farmers says "I have learnt so much about farming through Farmcrowdy and I am making much more money. With the money I have received, I can now pay to continue my educations."

Caribbean soilless solutions boost smart production

Creative technological solutions are being developed to transform traditional methods of crop production and help to achieve food security in the caribbean. In Barbados, hydroponic farm Ino- Gro Inc, for example, is using a 12m Shipping container with vertical tower a grow leafy green vegetables. Through a fully automated, online system, the growing environment can be monitored and controlled (i.e temperature, humidity, Co2 Levels and lighting) using aa smartphone app.

Hydroponics is a method of growing plant indoors, using nutrient solutions instead of soil . Energy- efficient Leds

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provide optimum light and the closed loop irrigation systems uses 85% less water than traditional outdoor systems. " Technology has been the main driver of change in most industries, and agriculture is no different." Says 23 year old warren Kellman, one of the Ino-Gro Inc Management directors. The tower can grow around 2,500 plants at any given time allowing high-density farming in a relatively small area. According to kellman, the container is equivalent to nearly 0.5 ha of Farmland and produce around 40kg of produce a week, including three different types of lettuce, mint, basil and edible flower. Demand is high and the produce sells out every week. "when we started, we wanted to find ways to make money but also do something good we import too much. The population of the Caribbean is only going to grow and we need to find more sustainable ways to produce enough food" Kellman explains.

In St Lucia, a local aquaponics facility is being touted by agricultural ministers in Antigua and Barbuda as a model for the rest of region to replicate, due to its high efficient use of space for economic food production. Green Havens Fresh Farm- an organic farm which specialies in integrated vegetable, tilapia and shrimp cultivation has 1- vertical vegetable beds and four fish tanks built above each other and is supported by an 80, 000 gallon solar- powered rainwater harvesting system. Lights on automatic timers and circulatory fans are also used to control the growing area and maximise production. The organic Aquaponic system, which was established in 2016, produces 1.8 t of lettuce each month and 7.25 t of tilapia annually

Crop Robotics

A low – cost robot Known as the digital farmhand has been developed to help reduce manual labour and enhance crop data collection for small scale horticultural farmers. Developed by engineers from the University of Sydney, the robot can perform simple task like pesticide spraying, seeding and weeding and can quickly be dismantled and reassembled on site. A mobile mount also enable data – such as individual plant weights – to be recorded and stored directly on a smartphone, providing farmers with detailed crop analytics. The Pacific Island Farmers Organization Network has signed a contract with the university to assist in a number of robotics field trials to be carried out on commercial vegetables farms in Samoa.

Interactive Farming

An interactive voice response (IVR) service is providing small holders with information for the prevention and control of disease in pigs in Uganda, Launched in May 2018 by the international livestock Research Institute, the IVR system offers 4- minute lessons delivered In the local language, to raise awareness of diseases like American swine fever among pig Farmers. The message can be updated and tailored to provide context – specific information. The system can also track which lessons the farmers has listened to and ask questions to gauge whether the information has been retained. The free IVR service is being piloted among 230 smallholders farmers in Masaka district and farmers can phone regardless of model of network provider.

Boosting rural resilience with climate risk management.

Without access to accurate and up to data weather data, ACP small holders have traditionally relied on predictions to take their decisions, but such predictions are becoming increasingly difficult. To foster greater climate resilience among farming communities, in 2016 the CGIAR Research program on climate change, Agriculture and food security (CCAFS) launched the 4 year Rwanda climate services for Agriculture (RCSA) programme. Supported by USAID, RCSA aims to improve the supply, communication and use of climate-related services across Rwnada. (Spore Magazine 2019)

RCSA is building on an existing initiative through which Rwanda's National Meteorological Agency combines data from local, ground- based weather stations from across the country, with rainfall and temperature satellite data. The satellites data, which extends 30-50 years into the past, also provides a historical source of information that allows stakeholders to better understand long-term climate trends. This information is then compiled into 'Maproom' -a freely accessible database of climate data. Providing information on trends in termperature and rainfall across time and at national, regional and district scales.

To improve the dissemination of climate information, and enhance farmers' ability to utilize the data themselves, RCSA has adopted the participatory integrated climate services for Agriculture (PICSA) approach that focuses on supporting small scale farmers in their planning and decision- making. PICSA begins with an initial workshop, where farmers evaluate their current farming strategies with reference to the risk identified using map room data. Trainers and extension staff use a seasonal forecast to update the risk identified during the first evaluation, and guide farmers to decide on any adjustment for the coming season.

Farmers participation in PICSA helps identify and support differing needs across Rwnada divers agro-ecology. But the approach has also proven effective at scale, with an estimated 75,000 farmers across the country having received in PICSA, as of April 2018. The project has also developed a network of trained farmers who are able to pass on their knowledge in the use of climate information to other farmers within their community.

A recent project assessment revealed that the vast majority of farmers that have r4eceived PICSA training found it useful- with seasonal forecast considered the most useful element of the training, and 93% of respondent having made changes to their farming operations. Anathase Mudenge, a farmer based in Bugesera district, dedicated a small portion of his farm to method learned through PICSA training including planting based in weather forecasting and the use of certified seeds – and witnessed a three- fold yield increase . : I now adhere to the planting time once I get the seasonal forecast and I always look for improved seeds." Mudenge explains.

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In recognitions of it accomplishment, RCSA was awarded the first Climate Agriculture project of the year Award, at the recent Africa Climate Smart Agriculture Summit in Kenya. Reflecting on the awards, Jim Hansen, leader of the CCAFS climate service and safety nets flagships program said, "innovative solutions such as……. PICSA have made it possible to make things previously only Demonstrated at pilot scale work for farmers on a national scale."

Putting digital technology in farmers hands

For decades, farm data across ACP countries has been collected by government, financial service providers and even mobile network operator, to provide insights into agriculture that can be used to shape and influence the sector from the top down. But with more than 40% of African household now belonging to farmers cooperatives – many of which digitally records and store their members digitally record and store their members farm data- decision -makers increasingly acknowledge that a more localized and inclusive approach to data may be the best way to transform agriculture.

Issue 89 of CTA's ICT Update focuses on 'Data4Ag' presenting a selection of eight case studies from across Africa that demonstrate the benefits of placing digital technology – with capacity to record more and more accurate data – in farmers' hands. This is no less clear than in Kenya where, in 2018 Agrocares piloted a mobile app that convert soil data gathered using a portable scanner into customized fertilizer recommendations. As result, farmers using the app reported more economic fertilizer usage and higher yields.

Automated Irrigation

A prototype irrigation system that prevents the over watering of crops has been developed in Kenya. The automated irrigation Manager system, created by scientist as Jomo Kenyatta University of Agriculture and Technology (JKUAT), can decrease a farms water usage by more than 25%. The technology uses 6cm sensors to read soil water levels and can be calibrated to adjust the water supply according to the moisture requirement of different crops. Pumps linked to the sensors feed water into the ground when moisture level drop below that needed by the plant. According to Wycliffe Obwoge, a JKUAT agronomist, the method also allows for the precise and economic applications, and boost crop yields by more than 50%.

Digital technology is increasingly being used to bolster farmers climate-resilience in the face of weather uncertainly. A CTA- supported Climate Livestock and market project in east Africa, for instance, provides pastoralists with weather information- including potential rainfall, temperature and evapotranspiration. A cloud-based weather information system draws this data from a host of local weather station. Where it is then delivered directly to the pastoralist' mobile phones via SMS – allowing farmers to better plan for, and adapt to, changing weather and climate conditions.

Weather and climate is also being employed across Africa to provide farmers with index-based insurance. The Dutch Environmental Analysis and Remote Sensing organization uses data gathered from meterological satellites to develop 'index thresholds' for specific climate factors.in Uganda for example, when evapotranspiration – a reliable indicator of plant growth – fall below the calculated threshold farmers in the insured area are automatically compensated without having to file a claim.

The latest ICT Update highlights the importance of a better connected and smallholders sector- which, it suggest, can be achieved by giving farmers and farmers organizations the tools to capitalize on existing digital technology.

Strategies for Scaling up Agriculture.

1. Formulate Equitable Agricultural policies (World Bank)
2. Design agricultural intervention to be gender inclusive (Igbokwe, 2023)
3. Assess whole- farm trade- offs and synergies for agriculture
4. Support farmer to farmer and community wide social learning
5. Know the drivers of the adoption of agricultural practices across different scales
6. Target the pathways to scale out agricultural technologist to farming communities
7. Prioritize agricultural options and benefits for greater impact (FMARD, 2016)
8. Invest in preserving and enriching the soil
9. Monitor agricultural interventions with a real-time participatory tool. (Spore Magazine 2019)

Conclusion

The integration of digital technologies and ICT with agricultural extension is essential for modern agricultural development. These concepts work synergistically to address challenges such as food insecurity, climate change, and resource scarcity. By leveraging these tools and approaches, stakeholders can create a more sustainable and resilient agricultural sector., The above innovations are worthwhile and are capable of boosting agricultural production in Nigeria, if adopted , thus helping to attain food security

Recommendations

As the world continues to face unprecedented challenges, the role of these interconnected concepts in driving agricultural transformation cannot be overstated. Policymakers, researchers, and practitioners must work together to promote the adoption of innovative technologies, The innovations discussed above are recommended for adoption by policy makers and farmers for the development of Nigerian Agriculture.

Dissemination mechanisms should be put in place to ensure that these innovations /technologies reaches the nooks and crannies of Nigeria

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