Transforming African Agriculture Through Artificial Intelligence: A Review of Case Studies

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Abstract
As global populations grow and environmental challenges intensify, the need for sustainable and efficient agricultural practices becomes increasingly urgent. technology, digital adoption, and ICT is essential for modern agricultural development. This work therefore reviewed and stressed the importance of use of artificial intelligence ln transforming the Nigerian and indeed African Agriculture, using case studies from Nigeria, Africa and out side Africa. Apps such as Data Matters, Agriproduct web , banking on A.I as well as initiatives such as, thinking of Africa, monitoring livestock vitals using machine learning, A,I potential for protecting against pests etc were reviewed as case studies .It was concluded that the use of artificial intelligence no doubt will transform Agriculture in Nigeria and indeed in Africa, it will help draw youths to get involved in Agriculture, how ever challenges exists which needs to be tackled. The following recommendations were made.- Sensitization is required to create awareness on the importance of using artificial intelligence in Agriculture. Training of farmers on the use of artificial intelligence is imperative .Government and other relevant major stake holders should look into the problem of high cost of network data, with a view to reducing the cost or providing subsidy or general reduction in the Cost of data, the problem of weak and epileptic data should be addressed
Keywords: African Agriculture , Artificial Intelligence, Case Studies, Digital, Transforming.

Introduction

. As global populations grow and environmental challenges intensify, the need for sustainable and efficient agricultural practices becomes increasingly urgent. technology, digital adoption, and ICT is essential for modern agricultural development. (Aker 2011) 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. Kudurumba *et al*, (2023) As the world continues to face unprecedented challenges, the role of these interconnected concepts in driving agricultural transformation cannot be overstated. (Olorunfemi *et al,* 2020) 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. (Hansen *et al* 2019)

AI is the broader concept of machine being able to carry out task in a way that is considered smart. The smart process include machine being able to function automatically, reason and learn by themselves. According to Claudia Ayin, as reported by Spore Magazine((2019) Machine learning is therefore a branch of AI that is the aspect of AI that allows computer to learn by themselves. "Machine Learning is therefore a branch of AI that is able to processes large Data sets and let machine learn for them Selves without having been explicitly programmed.

According to Markets and markets, an Indian research Company, in 2018 the worldwide AI in agriculture market was valued at € 545 million and, by 2025, is expected to reach € 2.4 billion as more and more smallholder farmers adopt new, data- driven technologies. With the help of data-driven technologies .

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.

The aim of this work therefore is to review case studies of use of AI to help drive home the importance of using AI in agriculture while calling for the adoption of the cases studies discussed.

Review of Case Studies

Making the most of machine learning on farm.

AI is the broader concept of machine being able to carry out task in a way that is considered smart. The smart process include machine being able to function automatically, reason and learn by themselves." Explains Claudia Ayin, an independent ICT Consultant. Machine learning is therefore a branch of AI that is the aspect of AI that allows computer to

learn by themselves. "Machine Learning is therefore a branch of AI that is able to processes large Data sets and let machine learn for them Selves without having been explicitly programmed." Spore (Magazine, 2019).

According to Marketst and markets, an Indian research Company, in 2018 the worldwide AI in agriculture market was valued at € 545 million and, by 2025, is expected to reach € 2.4 billion as more and more smallholder farmers adopt new, data- driven technologies. With the help of data-driven technologies. With the help of data scientist and big tech companies, small scale farmers in ACP countries are increasingly benefiting from the predictive abilities of AI and machine learning in order to access finance and insurance ,, predict yields and tackles pest and diseases, to run more profitable and 'smarter' sustainable farms.

The Potential of Digitalization

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 timely in attracting youth into agriculture, but there is need to link youth involved in digital agriculture with substantial financial inclusion, investment support from both the private and public sectors, and tailored agricultural trainings. (Spore Magazine, 2018)

Dr Akinwunmi Adesina, then president of the African Development Bank, emphasizes the potential of digital agricultural technology, such as digitally enabled 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 innovations.

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. 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 and higher incomes for farmers. Additionally, digital platforms such as weather forecasting apps and soil health monitoring tools enable farmers to make informed decisions, reducing risks and improving productivity. The integration of digital technologies into agriculture also facilitates traceability and transparency in supply chains, enhancing consumer trust and marketability of agricultural products. 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 agricultural 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, 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. (Spore Magazine, 2019)

Data Matters

In order to develop effective AI solutions and understand how smallholder Farmers use AI and machine learning, Agri-tech companies need high - quality data. The future of farming therefore lies in collecting data in order to maximise efficiency.

Availability of data is crucial. For example, climate uncertainly increases risk for farmers, "it's not raining less, it's just more variable," explains Wesley Black, a farm planner from Bloemfontein, south Africa. "AI will become small-scale farmers tackle climate change." So for climate resilience, crop and livestock insurance is a key element. However, data is crucial for insurers who need to know the livehood of crop failure; lenders need to know the likelihood of default, and traders need to know where surplus and deficit regions are. But few , if any, data resources exist that provide this kind of mass information at broad scale.

African scientist can now have access to free and open source satellite data as a result of a deal signed by the African Unin with the European Commission's Copernicus programme in 2018. But using satellite data to predict weather pattern is no easy task. IBM, For Example, processes data from multiple satellites using Watsons Decision Platform for Agriculture, which aims to combine predictive analytics, AI, weather data, and internet of things sensors to give farmers insights on ploughing, planting, spraying, and harvesting. Each satellites provides a digital image at different internals. Be it vegetation, soil and water cover, sea and land surface temperature or weather patterns. Using Varied AI to help small holders overcome agricultural challenges, such as drought, pest and diseases.

Using the AgriPredict web and mobile based platform, Zambian farmers are able to take photos of a suspected diseased plant/animal in order to receive a diagnosis, option for treatment, if required, as well as location of the nearest Agro-dealer. AgriPredict was founded as a result of Tuta absolute, a tomato disease, and advent of Fall Armyworm that caused significant crop lossess for Zambian Farmers in 2016. " we noticed that there were no tools to help farmers mitigate, prevent or even counter these challenges." Says Mwila Kangwa, AgriPredict CEO.

" AgriPredict has been cost saving; it ells me what disease is affecting my tomato, before, I would have had to employ a full time agronomist to help with the running of the farm, but ever since we started using AgriPredict, it cut down that cost completely; says farmers Yunike Phiri. Initial development of the platform was made possible with support from the SNV Netherlands Development Organization for a pilot project focusing on Zambia's tomato and maize value chains. The pilot, which was launched in October 2018, involves on app utilization, Site visits and gathering feedback from farmers. A social campaign '# coolfarmers' is also underway to promote the technology and increase interest among youths.

Maduka Emmanuel techniques and algorithms, IBM puts together all the data points to create a more in-depth and usable image of a farm: "Every day we receive satellite give you a portion of farm, but not one give you an actual representation of the farm. With AI, we fuse all these images together to get the full picture," explains Kommy weldemeriam, IBM Research Africa's chief scientist.

AI potential for protecting Against pests

Besides climate change, pests and diseases are a key challenge for small-scale farmers and is one that will be futher exarcerbated by climate variability. Each year, according to CABI estimates, about 50% of Africa's Crop are lost to pest and diseases.

"Hundred of millions of African farmers are already suffering from the effect of climate change, says David Hughes, an entomologist from Pennsylvania State University, and the leader of the project that created PlantVillage Nuru, an Andriod tool, which has been developed to diagnose crop diseases even without an internet connection, Developed by penn States, Plant Village and the International Institute of Tropical Agriculture, Nuru is used in several African countries, including in Kenya in collaboration with SelfHelp Africa to diagnose mite and viral diseases in cassava, as well as to identify fall armyworm infections in maize. Advice from experts – mainly at CGIAR, FAO and government – is sent offline and local language (currently in swahilli, French, Twi, Hindi, and English). Although still in beta testing, 28,000 cassava farmers across seven countries in Kenya will benefit from the tool this year. "Digital tools are increasingly becoming integral components… of identification, monitoring, training, and decision – making of globally-important crop pests and diseases," Hughes states.

A new AI tool that can predict crop growth and help protect vital food supplies from intensifying heat Is being added to Nuru. It uses data from a Unsatellite that tracks a decades worth of information about water availability, along with weather forecasting, to determine crop productivity. "AI offers the potential to get a single set of eyes to look at this problem," says Hughes. "Nuru is like an extension officer that is always there for farmers, in their fields."

Hughes believes that in low-income countries that lack human capital in fields like agricultural science, there is an opportunity to Use AI to help break the cycle of Poverty. Founded in august 2018, Agrix Tech, based in Yaounde, Ghana, is also using AI to Help Farmers tackles pests and diseases. Using a mobile phone app, farmers scan the leaf of an infected crop. The app uses an AI library to analyse the issue and provide treatment recommendations via text and voice messages, in customized African local Languages, for those who cannot read. According to Adamou Nchange Kouotou, Agrix Techs Founder and CEO, the app has a 99% Accuracy rate and most importantly, does not need the internet to function.

Banking on AI

In order to deliver economic and agricultural insights to farmers through out Africa, AtlasAI – a silicon valley tech company that addresses economic data and market intelligence needs in developing countries – uses technology that integrates satellites information and AI with high- quality data from the field . AtlasAI currently generates data for all African countries and is working with organization that serve government and farmers in multiple countries: "At AtlasAI, we use cutting edge AI and sattallite data to provide granular, accurate, and scalable data on agricultural outcomes across the continent," explains Marshall Burke, a professor at Standford University and one of AtlasAI's three co-founders.

For example, smallholders farmers are underserved by most financial markets: they have difficulty borrowing, they are often at a disadvantage in non-competitive trading environments. With AI and the rights data resources, this is an issue AtlasAI looks

to solve: "having accurate, low-cost data on smallholder farmers allows companies to actually design product and service that fit their needs," adds Burke.

Moving from products to homegrown services that incorporate advanced agricultural analytics and AI is something Hello Tractor, a US start-up based in Kenya and Nigeria, has made work. When Hello Tractor launched in 2014, their flagship product was an affordable, ultra-low horsepower, two wheel tractor fitted with monitoring technology. " we sold these to enterprising farmers or cooperative, who then accessed our tractor-sharing platform to identify and service additional demand from smallholders," explains Jehiel Oliver, Hello Tractors, CEO.

In January 2017, hello tractor made the strategic decision to focus more on their application than on the tractors themselves. It proved to be an effective model, allowing Hello tractor to capture 75% of private commercial tractor inflows to Nigeria, expands to five markets across Africa through strategic partnerships, and touch the lives of over 250,000 farmers.

Hello Tractor, in partnership with IBM, is now piloting an advanced agricultural analytics and decision-making tool that cuts across the mechanization ecosystem. Their data sets are used for fertilizer, seed and financial companies to access real-time, utilizing AI, farmers on the hello tractors platform gain access to timely and relavant information to increase yields tractor fleet owners receive insights to save time and earn more, and banks are empowered with information for better underwriting and portfolio management." Explains Oliver. "more specifically, we can apply machine learning to not help predict when farmers should receive their tractors services, but this data can also be ,mined to develop advice on what imputs should be applied and when, he says.

Thinking of Africa

From IBM to Deloitte, Amazon web service and google, there are many key corporate players which are working throughout the African continent and partnering with smaller companies and farmers to create locally-relevant AI-focussed solutions. It is necessary that AI tools are developed talking into consideration the context of local agriculture in Africa to ensure that these solutions are relevant and applicable to African. Agricultural system thus necessitating that African, who best understand African problems more intimetaly, be at the forefront of the development of these tools.

Microsoft, through its 4Afrika initiative, supports the digital transformation of noticed agricultural companies were trying to make sense of things like big data, AI, machine learning and analytics. These things rapidly ,moved their way into agriculture and most companies were not equipped to handle or deal with these new technologies. The need for technology companies like Microsoft to help them navigate this shift is critical," says Amrote Abdella, Microsoft 4Afrika's regional director, we belive technology enhancement have the potential to drive significant economic growth and societal impact, specifically because technology is able to bridge gaps in infrastructures that have previously kept people locked out of the formal economy and unable to access essential services on the continent. Working with Felix Musau from Kenya, Microsoft helped to develop AGIN, a mobile and Azure cloud-based service that connects farmers to much-needed credit service. Using mobile phones, farmers can capture information like farm size, location, soil composition and crops grown. Using Azure's built-in AI and machine learning tools, AGIN then helps farmers to establish a credit profile, allowing them to access resources like small loans, with credit lines they can use without ever visiting bank.

AGIN has served over 140,000 farmers in Kenya and facilitated over US$1.3million (€ 1.2 million) per month in transaction, including loans and insurance. After receiving financial and technical support from Microsoft 4Afrika, AGIN now has hopes to expand its reach to 300million farmers in sub-Saharan Africa by 2020.

Microsoft $Afrika also works closely with Tulaa, a commerce solution for Rural African Farmers. Tulaa uses mobile technology and mobile money to enable farms to save and borrow to purchase inputs and agricultural advice , and market their crops at harvest. Though $Afrika's AI PopUp Lab in Kenya, Microsoft assisted Tulaa with integrating machine learning into their model to assess credit worthiness. The ability for platforms like Tulaa to scale will be driven in part by our ability to harness the power of AI. The Zeitgeist now is around blunded services and platform solutions for smallholders farmers. One the major reasons that these models are emerging is the availability of AI and machine learning that was not there even 5 years ago," adds Miller-wise. CTA is also encouraging young developers to embrace data analytics and AI. During the 2019 edition of Pitch AgriHack CTA's competition supporting young digital agriculture starts ups- a special prize on "Data Analytics was awarded. The future of Agriculture is set to be more automated and data-driven. With innovative, African-driven solutions that make use of AI, smallholders farmers throughout the continent will be able to make smarter, data driven decisions, becoming more proactive and profitable, as they farm for the future. "were just at the start of a revolution in AI.," says Tom IIube, a futurist and the founder of the African science Academy in Ghana. " At the heart of AI is the algorithms that drive it. These algorithms define the future, we need to be defining the algorithms that tell us what the future looks like.

Monitoring livestock vitals with machine learning technology

In Uganda, a new technology is embracing AI and machine Learning to detect livestock diseases 2 days before they manifest, connect farmers to veterinary officers and monitor animal movement to avert theft. The innovation, dubbed Jaguza Luganda, constitutes a chip with a sensor that is connected to a radio-frequency identification (RFID) reader, and to users' mobile phones or computers. Since 2016, 18,000 Jaguza chips have been installed.

The chips and sensor technology is attached to an animal's ear, and RFID reader is able to detect the sensor in the chip from up to 300m away, or even futher is an antenna or rader is installed to bolster the frequency. The chips monitor vital information about the animal, including tempreture variations, feedings patterns and reproductive stages through the smart sensor, and is able to detect diseases 48hours before they manifest, allowing for timely medical attention. We use Jaguza to predict problems earlier, detecting cases like lameness or digestive disorder and provide recommendation to farmers on how to keep their cows healthy and improve the efficiency of their farms. Using these insight, we're already seeing a 35% increase in livestock production on our customer's farms" says Jaguza's founder Ronald Katamba.

The technology can also track livestock movement and alert farmers, through mobile messages, in the event that animals wander beyond farm boundaries. "Jaguza learns patterns about a cows movement from the sensor. We use this data to develop machine learning models and tensor flow algorithms." Explains Katamba. The technology has also been affective in reducing cases of theft that are rampant in Uganda's livestock rearing regions Charles Walugembe, who keeps 180 Cows began to trail Jaguza in 2018. He chipped 50 of his exotic cows that were bringing him the highest returns for their meat and milk. "for the longest time, we have been hiring armed guards to watch our cows. We have been spending almost half of what we earn from our livestock to pay these guards and other protection methods like fencing, but somehow we still manage to loose them. Sice using Jagauza, I am able to track movement no matter where I am and we haven't had any cases of missing livestock, he says.

Mobile Management

The Jaguza Livestock mobile application, which has 85 vaterians signed up and on standby to respond to farmers inquiries, compliment the sensor device. Using GPS, the app maps out the farmers proximity to a veterninary officer, and provides information on the vets specialization and availability. Information on good liestock management practices, including feeding and disease detection is also provided on the app, which is available on both android and IOS mobile not connected to the internet, the technology is accessible offline through a USSD code. Over 1,250 users have downloaded the app to access livestock information, and both the sensor device and app have attracted farmers beyond Uganda – in fiji, Mozambique and Namibia.

In a bid to streamline Livestock keeping the app also has a provision for record keeping, allowing farmers to records expenses and earning. Dan Kitsitu has been rearing cattle in Uganda for the last 15years and signed up with Jaguza in 2017 to monitor his 40 cows. Besides managing to tackle common diseases like foot and mouth disease, rinderpest and East Coatst Fever, he has used to spend a lot of money on veterinary services and medicine, especially due to frequent disease outbreaks from which I lost a number of cow. Beyond getting alerts on any health issues of my cows before they escalate, I have managed to bring down expenses like feed and supplement by up to50% using the electronic records keeping that allows me to identify where I am over spending." Says kisitu. "I have also been able to access information on good Farm management practices for feeding, vaccination and production, in place where extension services are no longer readily available due to the scarcity of government officers," he adds. (CTA, 2018)

Scaling out with drone sensors.

to cater to large farmers, Katamba is using drones fitted with high definition camera and thermal sensing technology. The drones, which are connected to the farmers' phones through a cloud based system, track the animals body tempreture and alerts the farmers in the case of sickness. Where it might usually take up to a whole day to count each cows reared by large scale farmers, the drones take on average 15minutes to do a headcount. "our drone tech uses "smart cameras" that are powered by AI and facial recognition to identify individuals animals in real-time. The camera monitor the animals" presence on the farm and send real-time information's to the farmers' mobile and computers there are two signs, a red one which indicates that the cow is fine," he explains.

Despite the success of the technology, which has seen Katamba invited Texas to promote Jaguza to livestock farmers in the area, he note that regulations for flying drones in Uganda are not yet in the place and poor internet connectively has stood in the way of project implementation. "Drones are still banned in Uganda despite the numerous benefits they deliver to ordinary people. We are in constant communication with the government to have a policy shift in recognizing these emerging technologies while investing in increasing internet connectivity to allow easier adoption of the innovations," says Katamba. Who obtained a license to operate only after receiving a letter from the chief of Defense Forces and the Uganda Civil Aviation Authority.

Jaguza is a member of the CTA AgriHack network, which supports young digital agriprenuers with capacity building opportunities, and was among the 2016 finalist of the pitch Agrikack competition. The company won first prize as a mature start-up in

the 2019 competition at the African Green Revolution Forum in Accra, Ghana.

Conclusion and Recommendations

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The use of artificial intelligence no doubt will transform Agriculture in Nigeria and indeed in Africa, it will help draw youths to get involved in Agriculture, how ever challenges exists which needs to be tackled

Recommendations

Sensitization is required to create awareness on the importance of using artificial intelligence in Agriculture.

Training of farmers on the use of artificial intelligence is imperative.

Government and other relevant major stake holders should look into the problem of high cost of network data, with a view to reducing the cost or providing subsidy or general reduction in the Cost of data.

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