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Blockchain Application for Sustainable Farming in Africa: Insights from Literature and Policy Documents

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Abstract. *Blockchain technology has been widely recognized for its potential to revolutionize various industries, including agriculture. In Africa, where agriculture remains a key economic sector, blockchain could enhance transparency, efficiency, and market access. However, adoption remains limited due to infrastructural, regulatory, and socio-economic challenges. This paper critically examines the role of blockchain in African agriculture, focusing on ten countries to assessing its adoption, necessity, and barriers. A review of the existing literature indicates that while blockchain has been successfully integrated into agricultural supply chains in some regions, African farmers continue to rely on traditional methods, mobile banking, and cooperative models. Using a qualitative research approach, the study investigates how blockchain aligns with technology adoption theories and explores whether it is essential for agricultural success. Findings reveal that while blockchain has potential applications in trade facilitation, fraud prevention, and land tenure security, its impact remains theoretical rather than practical due to limited digital literacy and policy gaps. The study contributes to the field by critically evaluating blockchain's real-world feasibility in African agriculture and suggesting policy-driven approaches for future adoption. Further research, including field studies, is recommended to better understand local implementation challenges.*

Keywords: Blockchain, Agriculture, Africa, Technology Adoption, Supply Chain, Digital Transformation.

Introduction

In Melanie Swans' book *Blockchain: Blueprint for new Economy* a framework for understanding the evolution of blockchain technology is introduced, categorizing it into three distinct divisions: Blockchain 1.0, 2.0, and 3.0. Blockchain 1.0 focuses on *cryptocurrencies* development, which is primarily as digital cash replacements. This phase encompasses applications like currency transfers, remittances, and digital payment systems, revolutionizing how we transact and manage money. Blockchain 2.0 which represents *contracts,* expands the scope of blockchain technology beyond simple currency transactions. It encompasses a wide range of economic, market, and financial applications, including stocks, bonds, futures, loans, mortgages, property titles, and smart contracts that automate agreements and transactions. Finally, Blockchain 3.0 envisions blockchain applications extending far beyond the realms of currency and finance, envisions blockchain *applications*. This phase explores the capability of blockchain technology to transform various sectors, including governance, healthcare, science, literature, culture, and art. This evidence gives us a clear picture of the usefulness of blockchain technology beyond currencies. However, the focus of this article will focus on Blockchain 3.0 thus blockchain *applications* (Melanie, 2015).

Blockchain has been around for almost two decades, and it has often been synonymous with cryptocurrencies like Bitcoin, and it operates as a decentralized and distributed ledger of

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transactions. Unlike traditional systems reliant on single central authority links the banks, blockchain records are maintained and validated by a vast network of computers globally. This decentralized structure empowers a community to oversee the records, ensuring no single entity possesses absolute control. Furthermore, the immutability of blockchain, which is the inability to alter or erase past transactions, guarantees the integrity and transparency of recorded information. This inherent security, derived from the distributed nature and peer-to-peer consensus mechanisms, safeguards the data from manipulation, a significant advantage over conventional centralized databases (Sarmah, 2018). Blockchain as an invention has gone through a long history of metamorphosis. In 1976, a groundbreaking paper explored the concept of a "distributed ledger," laying the foundation for decentralized record-keeping (Whitfield Diffie et al., 1976). Building upon this, Stuart Haber and Scott Stornetta (1991), introduced the crucial concept of timestamping data itself, rather than the medium it resides on. Concurrently, the emergence of "electronic cash" or "digital currency," pioneered by David Chaum, furthered the development of decentralized systems. These early concepts, such as e-cash schemes, grappled with the critical challenge of double-spending, where digital assets could be fraudulently replicated and spent multiple times. In 1997, Adam Back introduced "hashcash," a novel approach to combating spam emails. This inspired Wei Dai to propose "b-money," a decentralized currency system operating on a peer-to-peer network. Finally, in 2008, Satoshi Nakamoto, under a pseudonym, published a landmark paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System." This paper, which outlined a decentralized electronic payment system based on cryptographic principles, is widely considered the birth of blockchain technology as we know it. Nakamoto's ingenious solution addressed the critical double-spending problem by introducing a public ledger. This transparent record of all transactions allows for the verification of each coin's history, ensuring that it has not been previously spent and preventing fraudulent duplication. (Sarmah, 2018).

How does Blockchain really work? Blockchains are digital ledgers shared across a network of computers, eliminating the need for a central authority. Data is stored in "blocks," each containing a timestamp, transaction data, and a link (hash) to the previous block. This creates a chain, where altering one block changes all subsequent ones. Transactions are validated by network nodes, ensuring consensus even among potentially dishonest participants. This consensus problem has driven innovative blockchain designs. Like Bitcoin which uses "Proof of Work" (PoW), where "miners" solve complex computations to validate transactions and add blocks, earning new coins and fees. However, PoW's energy consumption and centralization risks have spurred interest in alternatives like "Proof of Stake" (PoS) where "validators" with staked coins are randomly selected to validate transactions, earning fees without the computational burden of mining. The transparency, security and trustworthiness of Blockchain has encouraged innovators to explore this invention in several sectors like, insurance, and even traditional banking. (Kamilaris Andreas et al., 2019, pp. 640-652).

Many years after the introduction of blockchain, there have been many different forms of knowledge transfer on this matter and one of the most innovative transfers have been in agriculture. Previously, consumers had difficulties in determining the state of the processes and distribution of Agri products to their local food market, but the adoption of blockchain into the agricultural sector, has made this possible. The agricultural sector involves numerous intermediaries. Food products often cross multiple checkpoints and borders before reaching the consumer. Moreover, modern supply chains grapple with numerous information-related challenges. These include fostering consumer trust, ensuring supply chain transparency, maintaining consistent product quality,

optimizing logistics, minimizing environmental impact, safeguarding personal consumer data, combating fraud, and guaranteeing food safety. With consumers becoming more concerned about the origins of their food and the spread of know through the internet, the old method of paper documentation was not enough because of its unreliability. Therefore, the search for the best way broke out and blockchain won the race (Ge Lan et al., 2017). Once a transaction is recorded on the blockchain, its immutability is ensured. This stems from the decentralized nature of the system. Unlike centralized systems, where a single entity controls and can potentially alter records, blockchain's distributed architecture involves replicating each transaction across the entire network. This redundancy makes subsequent modification or deletion practically infeasible, as it would require altering the copies held by all participants (Huma Hayat Khan et al., 2022, p. 347). This makes blockchain reliable with several key advantages relevant to supply chain applications. Its transparent nature, as a public ledger, allows for tracking the movement of funds and products throughout the chain. The technology's inherent security derives from data encryption and distributed storage, making unauthorized access or modification extremely difficult. Furthermore, blockchain can automate traditionally cumbersome processes associated with conventional payment systems, leading to potential cost and time savings for all stakeholders. Finally, the use of smart contracts ensures equitable treatment for all parties involved in a transaction. These self-executing contracts, triggered by pre-defined conditions, eliminate the possibility of unilateral alterations or interference, promoting fairness and trust (Arvind Panwar et al., 2023).

In Africa, blockchain technology has the advantage to revolutionize agriculture by enhancing transparency, improving supply chain efficiency, and reducing fraud (Kamilaris Andreas et al., 2019). It can enable secure and immutable record-keeping, this way, smallholder farmers will gain better access to markets and financial services (Sylvester G et. al, 2021). However, challenges such as high implementation costs, lack of digital literacy, and inadequate infrastructure negatively disrupts widespread. Furthermore, push backs from traditional stakeholders slow down integration efforts. Despite advanced interest, in research on blockchain applications tailored to Africa’s unique agricultural landscape, there is a gap that policy documents in research context were never studied. Which is why this study is needed to explore the different policy documents in other to make recommendations, fit for the African agriculture in the context of blockchain.

Literature review

Agriculture is the support system of many African economies, which contributes significantly to employment, food security, and economic stability. Despite its critical role, the sector faces almost never-ending challenges, including inefficient supply chains, limited market access, post-harvest losses, and financial exclusion (The World Bank, Unlocking Africa's Agricultural Potential, 2013). Many attempts to respond to this problem in the past, surfaced and recently, emerging technologies such as blockchain have been proposed as potential solutions to improve transparency, secure transactions, and streamline agricultural trade (Kamilaris Andreas et al., 2019). Although blockchain has won the hearts of many industries worldwide, its adoption and penetration in African agriculture remains limited, raising questions about its practical relevance, accessibility, and the barriers preventing widespread implementation.

This literature review explores the role of blockchain in sustainable farming across ten African economies selected based on their agricultural output, economic strength, and digital infrastructure. The selected countries, *Nigeria, South Africa, Kenya, Ethiopia, Ghana, Egypt, Rwanda, Tanzania, Uganda, and Morocco*, represent a diverse range of agricultural practices and

technological development. Some nations, such as Kenya and Ghana, have begun exploring blockchain for supply chain transparency and financial inclusion, while others, like Ethiopia and Nigeria, continue to face infrastructural and regulatory challenges that limit its adoption (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022). By analysing existing literature, policy documents, and case studies, this review aims to address three key questions: (1) How successful are African farmers in using blockchain technology? (2) Is blockchain important for agricultural success in these economies? (3) What are the primary obstacles preventing widespread adoption? If these factors are understood, it will be easy to know if blockchain's potential in Africa's agricultural landscape is necessary and if it serves as a viable tool for enhancing sustainability or if other solutions may be more practical for the region's unique challenges.

The agricultural sector in Egypt is one of the most important in Africa, which contributes to approximately 11.6% of the country's GDP and employs over 19% of its workforce (World Bank Group, Agriculture, forestry, and fishing, value added (% of GDP), 2023). Although blockchain has potential applications in areas such as water management, its implementation in Egyptian agriculture remains limited. However, there are some early-stage pilot applications of blockchain initiatives being explored in Agri-finance and land registry systems. For instance, utilizing blockchain technology to enhance land tenure security to secure land registries to prevent land disputes ensuring transparent transactions, particularly for smallholder farmers and for food traceability in high-value export crops such as citrus and olives, which are key components of Egypt's trade with the European Union and Gulf markets (Eiman Rashed, 2016).

While blockchain presents many opportunities Egypt, it is not necessarily a requirement for its agricultural success. Agricultural success in Egypt has historically been driven by large-scale irrigation projects such as the *Toshka Project* or the *New Valley Initiative*, which focus on reclaiming desert land for farming (Jeroen Warner, 2013). Furthermore, Egypt has made progress in digital agriculture without fully incorporating blockchain; for instance, the government in collaboration with the *National Authority for Remote Sensing and Space Sciences (NARSS)* the efforts to implement smart agriculture projects that utilize sensors, GIS, the Internet of Things (IoT), and information and communications technology (ICT) to enhance irrigation practices and monitor soil and plant health (National Authority for Remote Sensing & Space Sciences, 2024). Furthermore, the *Egyptian Space Agency (EgSA)* collaborated with the Food and Agriculture Organization (FAO) to expand the use of remote sensing applications in agriculture, with the purpose to improve water management and agricultural productivity in the region (FAO, 2024).These advancements suggest that Egypt's agricultural progress does not solely depend on its adoption, even if blockchain could enhance certain aspects of the sector.

Aside the successes achieved without blockchain, several key factors which hindered the widespread use of blockchain in Egypt's agricultural sector were discovered. Regulatory and policy challenges can be named as a factor to this barrier because currently there is no comprehensive legal framework to govern blockchain applications in Egypt's agricultural sector. Although the country has enacted regulations for fintech and digital banking, clear policies on blockchain use in land tenure, Agri-finance, and supply chain management are still under development (Hania Meshref et al., 2023). Other barriers include digital illiteracy among rural farmers and internet and infrastructure limitations within the rural farming communities (PWC, 2022).

The next country to review is Ethiopia, which is known to hold a significant position in the global coffee market, contributing up to 30% of the country's export earnings and supporting over

15 million smallholder farmers' livelihoods (Adong A et al., 2024). Blockchain technology, in recent years, has attracted attention as a reliable tool to enhance transparency and ensure fair trade in Ethiopia's coffee supply chain, but despite promising initiatives, there is a limitation in large-scale adoption due to infrastructural, financial, and regulatory challenges. Despite the challenges which has been noted, the country has made the effort by incorporating blockchain technology in their coffee supply chain. *The Ethiopian Coffee* and *Tea Authority*, in 2021, signed a partnership with *IOHK*, the developer of the *Cardano blockchain*, to create a digital certification system for Ethiopian coffee to improve traceability and the verification of the genuineness and quality based on blockchain immutable record (Staff Writer, 2024). The technology was also meant to ensure that farmers were well compensated and protected from dubious middlemen.

Another important project is the Ethiopian government's collaboration with global blockchain firms to track coffee beans from farm to consumer (Staff Writer, 2024). With the use of smart contracts technology, buyers and exporters have the freedom to confirm details about coffee origin, farming methods, and fair-trade compliance. Considering all the advancements and successes achieved, blockchain use in Ethiopian agriculture remains highly concentrated in the coffee industry, with little expansion into other agricultural sub-sectors. If the country will fully adopt this innovation into their day-to-day agricultural practice, they are like to enjoy more from blockchain's benefits although, their agricultural success does not solely depend on blockchain. For instance, Ethiopia has focused on climate-smart agriculture and irrigation expansion, enabling increased productivity in staple crops such as teff, maize, and sorghum (Getasew Daru Tariku et al., 2024). Farmers would rather prioritize a better input into production than digital technology.

Aside, the reasons farmers have not to prioritize blockchain as a major success factor, there are barriers which limits the adoption across Ethiopia's agricultural sector. They have serious internet connectivity and face digital infrastructure issues especially in rural farming areas. According to research conducted, internet access in Ethiopia was about 16% in 2022 and this indicates of the lowest internet penetration rates on the continent (Adam L et al., 2024). Also, the country lacks reliable regulatory framework for blockchain adoption in agriculture. Although in recent times Ethiopia has taken the initiative to integrate digital technologies into agriculture, through the Digital Agriculture Roadmap (DAR) 2025-2032 (ENA, 2025). However, no active policy on this subject has been issued to encourage the adoption of this technology.

Another global leader in cocoa production is Ghana, which supplies about 20% of the world's cocoa beans (Evan Selinger, 2012). Since cocoa plays an important role to the country's economy, several blockchain-based initiatives have been explored in recent years as a tool to enhance transparency and to address troubling issues such as middlemen exploitation, among others. To control this pressing issue, companies such as *Farmerline* and *AgUnity*, Ghanaian agritech firms, were set up to implemented blockchain technology in the cocoa sector. For instance, *Farmerline* set up to reduce reliance on intermediaries in other to improve supply chain traceability and facilitate direct payments to farmers (Farmerline, 2024). Also, *AgriUnity* a company that uses blockchain application to enhance cooperation among smallholder farmers by providing digital record-keeping pioneered a project in Ghana to deploy technology platform for two-hundred and fifty farmers (AgUnity, 2022). Despite these efforts, blockchain adoption among Ghanaian farmers remains limited. Most of these initiatives are still in pilot phases, and only a fraction of farmers benefits from blockchain-based solutions. While these initiatives are good, the question is if blockchain is necessary for Ghana's agricultural success? Ghana has thrived without blockchain, and this can largely be due to structured institutional frameworks such as the *COCOBOD*, which

is in charge to regulates prices, provides extension services, and facilitates financing for farmers (Ghana Ministry of Information, 2024)

However, despite century long dependency on traditional skills, blockchain could add value by improving *traceability*, which is increasingly demanded by global buyers who seek ethically sourced cocoa (Michaela Balzarova et al., 2022). Additionally, blockchain can make it easier for smallholder farmers to secure microloans and insurance (AgUnity, 2022) since traditional banking systems often exclude rural farmers due to a lack of credit history or collateral. Despite the positive and innovative offers that blockchain could present to Ghanaian farmers, there are some limitations which stems from the challenge of no specific regulatory framework for blockchain in agriculture. In Ghana, although digital agriculture policy has been designed to support e-agriculture (Degila J et al., 2023), there is no policy specifically for blockchain implementation in this sector. The absence of clear policies discourages investment in blockchain-based solutions. Another barrier is poor digital illiteracy where a large proportion of Ghanaian farmers, especially in rural areas, have low levels of digital literacy and it is mostly the use of simple devices like mobile phones (not smart phones), radio, and TV (Abdulai A et al., 2023).

When it comes to a well-developed agricultural sector in African, Morocco is considered as part of the count, positioning itself as a leader in the exportation of high-value crops such as citrus, olives, and vegetables, supplier to European and Middle Eastern markets (Statistia, 2025). Since it engages in export-driven agriculture, Morocco has explored blockchain for supply chain traceability, to ensure food safety and improve trade transparency (Boutkhoum O et al., 2021). Morrocco invested in a pilot project which uses of blockchain for trace citrus exports to the European Union, and allows Moroccan farmers and exporters to track produce from farm to market, which reduces fraud and enhance consumer confidence (Moroccan Customs, 2021). Aside exportation, blockchain has also been used as a tool in Morocco's efforts to improve land tenure security to reduce disputes and increase access to credit for farmers (Annie Thompson, 2020)

It is undebatable that blockchain has the potential to address inefficiencies in Morocco's agricultural sector, however, the country's agricultural advancements have primarily been driven by its sophisticated irrigation infrastructure, government subsidies, and well-established export networks. The *Green Morocco Plan (Plan Maroc Vert),* is an agriculture initiative which focuses on modernizing farming practices, improving irrigation efficiency, and expanding high-value crop production (Agency for Agricultural Development, 2008). The plan has successfully increased agricultural productivity without relying on blockchain and it suggests that other technological which provides substantial role in Morocco's success. Additionally, Morocco has invested in smart irrigation systems, including the use of artificial intelligence (AI) and remote sensing to optimize water use. These technologies help farmers manage water resources more efficiently in a country where water scarcity is a growing challenge (Saoudi, 2024). While Morocco has embraced digital transformation, it still faces regulatory uncertainty where clear regulations on blockchain's role in agriculture are still lacking creating hesitation among investors and agribusinesses that might otherwise implement blockchain solutions (Boutkhoum O et al., 2021). Also, rural farming regions still face challenges in internet access and digital connectivity. Blockchain applications require reliable internet access to function effectively, which can be a limiting factor (Rossi, 2025).

Another country which is tagged, the largest African economy, is Nigeria and it also has a heavily dependence on agriculture, and it contribute to approximately 22.72% to its Gross Domestic Product (GDP) as at the year 2023 (World Bank Group, Agriculture, forestry, and fishing, value added (% of GDP), 2023). As the world's leading producer of cassava and yams and also

playing an important role in the production of rice, maize, and cocoa Nigeria's agricultural sector still struggles in low supply chain management, financial discrepancies, and post-harvest losses (O. Obi-Egbedi et al., 2024).

The country, since 2020 have endeavoured to explore blockchain technology adoption to enhance transparency within agriculture but it remained limited. However, some agritech startups and fintech companies piloted blockchain-based solutions: for instance, in 2020, the Nigerian Export Promotion Council (NEPC) initiated discussions on leveraging blockchain for enhancing transparency in the cocoa supply chain, ensuring that smallholder farmers receive fair prices and reducing fraud in export documentation (Hakeem Gbadamosi, 2023). Also, Agri-tech firms like *FarmCrowdy* have incorporated digital tools, including blockchain-backed smart contracts, to facilitate investment in small-scale farming, (Atuahene-Gima et al., 2019). Despite these potential benefits blockchain brings to the table, agriculture in Nigeria has thrived without its integration. The government's focus is more on mechanization, irrigation expansion, and mobile-based financial services like e-wallets for input distribution, which have proven effective in supporting smallholder farmers (Temple Uwalaka, 2017), and this is one of the factors that has prevented the government from incorporating blockchain into the agricultural sector. Other factors include the high cost of investment needed to implement this technology (Rishi Raithatha, 2020) . There is also a factor of infrastructure and connectivity challenges, since blockchain requires reliable and stable internet and electricity access (Michael Edun, 2023).

Countries like Kenya and South Africa have also been at the forefront of digital innovation in Africa, particularly in mobile banking and fintech (Pan Finance, 2022) and also standing out as Africa's most industrialized nations, with a sophisticated agribusiness sector that integrates modern technology into farming, respectively (DR John Mutunga, 2023). Whiles Kenya's interest in digital innovation has led to pilot programs which have introduced blockchain to agricultural projects such as *Agri-Wallet*, a blockchain-based mobile platform that enables farmers to receive and store digital payments, facilitates secure transactions between farmers, suppliers, and buyers (Yameo, 2017) , and *Twiga Foods*, an initiative which leverages blockchain to streamline supply chain management and improve access to markets for small-scale farmers (Mulinge W et al., 2024), South Africa on the other hand, has utilized blockchain applications for supply chain transparency, ensuring the traceability of products from farm to market especially for exports to Europe and North America (Roberto Mavilia et al., 2021) and also to create tamper-proof digital land registries, which ensures that land ownership is secure and easily verifiable (Ledger Insights, 2019)

Despite the successes both countries have achieved with blockchain technology, they do not name it as a fundamental reason for their agricultural success. For instance, South Africa has well-established export markets for fruit, wine, and livestock, supported by trade agreements with the European Union (European Commission, 2024). Also, they have support from government and research institutions like the Agricultural Research Council (ARC) and Stellenbosch University which plays an important role in developing agricultural innovations, focusing more on climate resilience, biotechnology, and water management rather than blockchain. Similarly, platforms in Kenya such as *M-Farm* and *iCow* provide farmers with market price updates, weather forecasts, and livestock management tools via mobile technology (Joe Brock, 2015). Again, the country benefits from *Kilimo Salama*, a weather-based index insurance scheme, which uses mobile technology to provide smallholder farmers with insurance coverage, and this ensures financial resilience against climate risks (International Finance Corporation, 2015). The factors listed above, prove that, these countries have a achieved success without the help of blockchain. Furthermore,

there are challenges that have slowed down the full adoption of blockchain in these countries. Some of these include trust-based agricultural transactions since many Kenyan farmers still prefer traditional transactions. The adoption of blockchain will require a cultural shift, as many farmers rely on informal agreements and community trust rather than digital contracts (Abdul-Rahim Abdulai, 2022). Also, there is a challenge of digital illiteracy which keeps them focused on basic technology and mobile banking (Dennis Junior Choruma et al., 2024). Likewise, South Africa also faces similar drawbacks like digital illiteracy and limited digital infrastructure especially in the rural regions. to adopt blockchain. Furthermore, existing alternatives like digital tools for supply chain, mobile banking, and land registration reduce the need for blockchain adoption.

The last set of African countries to review are also superpowers in agriculture. Contributing to approximately 33% of GDP and employing about 70% of the population, agriculture has been a fuel to Rwanda's economic growth (FAO in Rwanda, 2025). Therefore, the government has initiated digital technologies, including blockchain and has implemented policies to encourage efficiency and sustainability in the agricultural sector (FAO et al., Digital Agriculture Profile Rwanda, 2020). Also, in Tanzania, 27% to the country's GDP is from agriculture, and over 70% of the workforce are from this sector. The country is a major exporter of coffee, maize, and cashew nuts. (FAO in Tanzania, 2025). Another country whose economy has thrived on agriculture is Uganda, with 25% contributing to the country's Gross Domestic Product (GDP) and employing approximately 70% of the population (World Bank Group, Closing the Potential-Performance Divide in Ugandan Agriculture Fact Sheet, 2018). The nation has a growing interest in financial technology (fintech) solutions, including mobile payments and digital lending platforms, and this motivated some pilot projects in agricultural finance and insurance, including blockchain-based platforms to improve credit accessibility for smallholder farmers, enabling them to secure loans without traditional collateral requirements (FAO, 2023).

For Rwanda, Tanzania and Uganda, while blockchain holds promise in addressing inefficiencies within the sector, it is not necessarily the most critical factor for success. Rwanda has achieved success through innovations like satellite imaging, AI-powered climate prediction, etc, enabling farmers to adapt to climate change and improve productivity (Bright Aboh, 2020). Also, platforms such as *Umurenge SACCO* digital banking have been instrumental in facilitating financial inclusion among smallholder farmers. Unlike blockchain, which requires specialized infrastructure, mobile banking solutions have achieved widespread adoption without significant technological barriers (Alliance for Financial Inclusion, 2014). Tanzania's success has been based on improvements in farming techniques, infrastructure, and market access. For instance, the government has invested in digital finance and mobile money solutions, such as M-Pesa and Tigo Pesa, to allow farmers to receive payments electronically and access credit (Yogesh Rawal, 2021). Lastly, just like Tanzania, Uganda's significant contribution to its agricultural success has been the expansion of mobile money services, such as MTN Mobile Money and Airtel Money, which allow farmers to access financial services without requiring a formal bank account (Financial Sector Deepening Uganda (FSD Uganda), 2017). However, while success has been achieved outside blockchain technology, its potential to stimulate transparency and fairness in trade is inevitable. Further analysis shows that these countries have similar barriers when it comes to blockchain adoption. For instance, they have high resistance to change due to middlemen, irregularities in policies that scare investors, digital illiteracy among farmers, limited infrastructure, etc., and the solution is for these barriers to be addressed.

Methodology

The present methodology represents an integrative approach to blockchain application for sustainable farming in Africa. This study adopted a mixed-methods approach, integrating qualitative research which examined existing literature, policy documents, and case studies of blockchain applications in agriculture and quantitative research which also analyzed statistical data on agricultural production, blockchain adoption rates, and technological infrastructure in selected African countries to help explore the application of blockchain technology in sustainable farming across these nations.

The study was guided by three research questions: (1) How successful are African farmers in using blockchain technology? (2) Is blockchain important for agricultural success in these economies? (3) What are the primary obstacles preventing widespread adoption?

For literature review, we analyze secondary data such as reports from organizations such as the Food and Agriculture Organization (FAO), World Bank, and World Bank Group and policy documents from African governments. We also analyzed the topical literature retrieved from Google scholar, Scopus, Science Direct and Google Search using the keywords in *"Sustainable farming and blockchain", "Blockchain in African agriculture", "Barriers to blockchain adoption in farming"* and similar others. Also, for case study, a real-world blockchain implementations in African agriculture was examined from countries such as Kenya, Ghana, Ethiopia and many more. Again, government reports and policies on blockchain adoption in agriculture of African countries such as Nigeria, Kenya, South Africa, etc. was reviewed.

For quantitative data collection, agricultural production statistics, blockchain adoption data from sources such as World Bank, Food and Agriculture Organization (FAO), World Bank Group and many others was reviewed. Furthermore, farmer survey data if available on blockchain awareness and willingness to adopt the technology was reviewed.

The reason for choosing the mixed-methods approach allows for a better understanding of the role of blockchain in African agriculture, ensure a strong theoretical foundation, to provide real-world insights and objectivity. However, since the research only focused on secondary data there is a limitation in the understanding of the practical challenges faced by African farmers.

Results and discussions

According to the (The World Bank, Agricultural Growth and Digital Transformation in Africa, 2022) a major barrier to blockchain-based solutions is internet connectivity where only 28% of the population in Sub-Saharan Africa has reliable access. Also, a study by (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022) highlights that only 10% of African farmers have access to digital tools beyond mobile money, indicating that blockchain technology remains out of reach for most smallholder farmers.

This review critically examines the role that blockchain plays in African agriculture, focusing on its adoption, necessity, and barriers in ten, countries including Tanzania, Ghana and Egypt. These results align with prior studies (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022) and the (The World Bank, Agricultural Growth and Digital Transformation in Africa, 2022) that highlight similar challenges in other developing regions. The research question regarding blockchain's importance for agricultural success were partially validated. This aligns with prior research (Pan Finance, 2022) which suggests that digital finance has had a more immediate impact on smallholder farmers than blockchain. Also, the research question about the barrier to the adoption of blockchain in farming which is limited by

infrastructural, financial, and regulatory constraint were fully validated (Abdul-Rahim Abdulai, 2022) and (Dennis Junior Choruma et al., 2024). Theoretically, the study supports technology adoption models, such as the Technology Acceptance Model (TAM), by proving that perceived usefulness and ease of use strongly influence blockchain adoption. However, the findings also suggest that socio-economic factors and policy frameworks does play a crucial role, framing an adaptation of existing models to the African agricultural context. Future research should further explore strategic policies that can motivate blockchain adoption in Africa. It should also, explore ways to encourage rural farmers to find interest in learning about new technology or to have a posisitive culture shift from traditional farming. For easy reference, Table one has been created to represent the summary of the findings for all ten countries regarding blockchain acceptance and adoption in African agriculture and it seeks to answer the questions if blockchain is essential for agricultural success, barriers to blockchain adoption and if utilizing blockchain can bring any success in African agriculture.

Table 1. A comparative table summarizing the findings for all ten countries regarding blockchain adoption in African agriculture

Country	Success in Utilizing Blockchain	Is Blockchain Essential for Agricultural Success?	Barriers to Blockchain Adoption
Egypt	Discussions on blockchain for land registries and water management (National Authority for Remote Sensing & Space Sciences, 2024).	Not essential; success relies on advanced irrigation and digital agriculture (Jeroen Warner, 2013).	Unclear regulatory framework, infrastructure limitations, and costs (PWC, 2022).
Ethiopia	Blockchain piloted in coffee certification (Cardano partnership) (Staff Writer, 2024).	Not yet essential; traditional supply chains still dominant (Getasew Daru Tariku et al., 2024).	Internet access limitations, policy uncertainty, cost barriers (Adam L et al., 2024).
Ghana	Cocoa sector exploring blockchain for fair trade and traceability (Farmerline, 2024).	Potentially essential for export-driven industries (Ghana Ministry of Information, 2024).	Limited farmer education on blockchain, implementation costs (Abdulai A et al., 2023).
Kenya	Early adoption in agrifinance and supply chain traceability, linked to mobile banking (Yameo, 2017).	Somewhat essential for financial inclusion, but traditional methods still dominate (Joe Brock, 2015).	Infrastructure challenges, regulatory gaps, and digital illitracy, (Dennis Junior Choruma et al., 2024).
Morrocco	Blockchain considered for export market traceability (Boutkhoum O et al., 2021).	Not essential, as irrigation and export policies drive success (Agency for Agricultural Development, 2008).	Cost of implementation, regulatory uncertainty (Boutkhoum O et al., 2021).
Nigeria	Limited blockchain adoption in agriculture; fintech and mobile banking are more widespread (Hakeem Gbadamosi, 2023).	No, agriculture thrives through traditional and digital finance solutions (Temple Uwalaka, 2017).	Low digital literacy among farmers, high costs (Rishi Raithatha, 2020).
Rwanda	Government-led digital transformation policies include blockchain exploration (FAO et al., Digital Agriculture Profile Rwanda, 2020).	Not currently essential, but has potential in land tenure security (Bright Aboh, 2020).	Infrastructure constraints (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022).

Country	Success in Utilizing Blockchain	Is Blockchain Essential for Agricultural Success?	Barriers to Blockchain Adoption
South Africa	Some blockchain use in agribusiness, especially for wine and fruit traceability (Roberto Mavilia et al., 2021).	Not essential, as agribusiness is already well-developed (European Commission, 2024).	Lack of widespread digital literacy among small farmers (Agricultural Research Council (ARC), 2020).
Tanzania	Some discussions on blockchain for agricultural trade (Tanzania Ministry of Agriculture, 2022).	Not a necessity, as traditional methods remain effective (Yogesh Rawal, 2021).	Digital literacy, cost concerns, and low awareness (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022).
Uganda	Interest in fintech applications for farmers, limited blockchain implementation (FAO, 2023).	Not essential yet; mobile banking provides financial inclusion (Financial Sector Deepening Uganda (FSD Uganda), 2017).	Lack of blockchain policies (FAO et al., Status of digital agriculture in 47 sub-Saharan African countries, 2022).

Source: Authors' own research.

Conclusion

The study focused on the role of blockchain in African agriculture, examining its adoption, necessity, and the barriers preventing its widespread use. The findings highlight that some barriers like low digital literacy, regulatory uncertainty hinders the adoption of blockchain despites its benefits. Addressing these barriers requires targeted policy interventions, investment in digital infrastructure, and localized capacity-building initiatives. For instance, a country like Ghana have demonstrated agricultural success through alternative means, such as cooperative models. The research's contributions rely on its critical assessment of blockchain's practicality in African agriculture and its alignment with technology adoption theories while identifying key research gaps such as the insufficient review in policy documents. Future research should investigate strategic policies that can help adopt the blockchain models and assess their long-term sustainability. The research relied mostly on secondary data which was a major limitation, and this may not fully capture local farmers' perspectives. In future, study should invest in field studies and case-specific analyses to gain deeper insights into blockchain's real-world applicability in African agriculture.

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