The blockchain technology for financial inclusion of smallholder farmers in Africa

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Abstract. Blockchain is a recently developed technology, its applications are becoming increasingly popular in various use cases. This work focuses on the potential application of blockchain technology for the financial inclusion of smallholder farmers in Africa. Based on the analysis of World Bank Global Findex data, the results highlight the failures of Africa's present financial system and serve as a foundation for a discussion of possible blockchain solutions to lower the continent's current financial exclusion rate. Moreover, a case study of a blockchain pilot project in Kenya is examined to investigate this blockchain application.

Keywords: Blockchain, Financial Inclusion, Agriculture, Supply chain, Africa.

1   Introduction

In Africa, the agricultural sector is dominated by smallholder farmers [1], they are defined as individuals who currently live in rural areas with a modest asset base and less than 2 hectares of farmland and lack the resources to meet their fundamental requirements and maintain their subsistence level [2], they hold about 80 percent of all farms in sub-Saharan Africa (SSA) and up to 90 percent of productivity in some SSA nations [3]. Thus, increasing their capacities will enhance Africa's production and, more crucially, aid in alleviating food insecurity in Africa.

By having access to financial services, smallholder farmers can pay the high up-front expenses of high-quality seed and fertilizer, and buy or rent equipment that improves productivity while decreasing the need for manual labor. Moreover, crop insurance can assist farmers in mitigating the negative externalities of climate change such as natural disasters. Therefore, expanding access to finance for smallholder farmers is a key factor in achieving long-term, sustainable increases in smallholder farmers' productivity and income, alleviating poverty and boosting economic development [4].

However, the agriculture sector in Africa has been excluded from access to finance. The agricultural industry receives only an estimated 1% of African bank loans. In the second quarter of 2019, Only 4% of bank loans in Nigeria go toward the agricultural sector [5]. In Rwanda, agricultural finance is still in its infancy, and just 7% of credit flows to agriculture [6]. Less than 20% of smallholder farmers worldwide have agricultural insurance, and less than 3% do so in Sub-Saharan Africa [7].

Multiple barriers can prevent smallholder farmers from access to financial services, including lack of credible production data, collateral, credit histories and agriculture-specific risks such as variable weather and price fluctuations [8]. Financial institutions are more likely to provide financial support to large-scale farms and agribusinesses whose production capabilities and financial stability are well-known.

The challenges of financial inclusion can be overcome by deploying blockchain technology [9]. Due to its distributed, immutable, and smart contracts features [10], blockchain technology allows the creation of a decentralized, highly transparent, and highly secure system of records without requiring a central authority or a trusted third party [10].

As a result, this work aims to analyze the potential application of blockchain technology for the financial inclusion of smallholder farmers in Africa. Section 2 provides a literature review of blockchain technology. In section 3, the current status of financial inclusion in Africa is analyzed using World Bank Global Findex data. Section 4 discusses the possible blockchain solutions to lower the continent's current financial exclusion rate. In section 5, a case study of a blockchain pilot project in Kenya is examined to investigate this blockchain application. Section 6 examines blockchain implementation challenges.

2   Blockchain technology

Blockchain technology is a digital ledger that consists of a chain of blocks [11]. The block is assigned a unique hash value by a cryptographic algorithm known as hashing and each block contains the previous block's hash [11]. Consequently, any modification to a single block would result in a change in the hashes of the blocks that follow. A group of computers known as nodes are responsible for the approval, and execution of the blockchain [12]. Every node in the network has a complete copy of the ledger, the nodes work together as a peer-to-peer network with no single person having control over the system, making the blockchain decentralized and distributed [11]. The blockchain is immutable which means that the block data cannot be altered and any manipulation of records would affect the whole system since the blockchain uses cryptographic hash algorithms to link blocks [13]. Smart contracts are a key feature of blockchain, they are computer codes that run on the blockchain, which execute automatically when pre-arranged conditions are satisfied without needing a trusted third party [14]. In a blockchain network, consensus protocols allow the nodes to agree on a single record and ensure that all transactions performed on the blockchain network are verified and approved [10]. Proof of Work (PoW) and Proof of Stake (PoS) are the widely used consensus protocols, other consensus protocols have been developed such as Practical Byzantine Fault Tolerance (PBFT), Proof of Elapsed Time (PoET), Proof of Authority (PoA) and Proof of Space (PoSpace) [10].

3   Financial inclusion in Africa

"Financial inclusion is the access to appropriate, low-cost, fair and safe financial products, and services from main-stream service providers"[15] which means the financially excluded individuals cannot benefit from basic financial services such as Insurance, Bank accounts, and affordable credit [15]. The key source of data about financial inclusion in Africa is The Global Findex from the World Bank, which is regarded as one of the most significant contributions in this topic since it covers financial data from 148 countries, 42 of which are African. The versions of the World Bank dataset are reported for 2021, 2017, 2014, and 2011. The Global Findex Database contains almost 300 indicators on issues like account ownership, payments, savings, loans. Findex information is provided for each indicator by nation, region, and income category.

Figure 1 shows the nonuniform of the account owners' distribution. For example, just 40% of adults in Africa have an account at a formal financial institution or via mobile payment services, the lowest percentage of any continent. Accounts are not spread uniformly among the population even within Africa, as seen in Figure 2. The highest level is seen in South Africa, the most developed nation on the continent, followed by Kenya and Namibia, South Sudan has the lowest rate, with just 5.83% of the population having a bank account. Figure 3 shows a significant worldwide gender difference in bank account ownership, with the highest percentage being observed in Sub-Saharan Africa, where just 34% of women have bank accounts compared to 46% of men. As a result, cultural and religious factors in Africa can play a role in reinforcing the existing gender gap. In order to achieve financial inclusion, financial literacy is crucial. The proportion of persons who have an account is actually lower among those with the fewest levels of education. Just 24% of those with primary education or less have a bank account opposed to 56% of those with secondary education or more (Figure 4). A further factor to consider is digital payments, 92% of North American account holders have made at least one digital payment, followed by Europe and Central Asia (84%) as seen in Figure 5. In the case of Africa, the proportion is smaller and not homogeneous among nations. 46% of the African population as a whole made at least one digital payment. Yet, in Kenya and South Africa, this kind of payment is almost predominant among account holders, but in North African nations such as Algeria and Egypt, it is used by less than 10% of the population (Figure 6).Yet another factor to take into account is borrowing behavior, Figure 7 shows that the majority of the African population (41%) borrowed from family and friends rather than financial institutions which only represent 10%, contrary to developed continents (North America and Europe). This can be explained by the high interest rates and the issue of access to financial services for people living in rural areas.
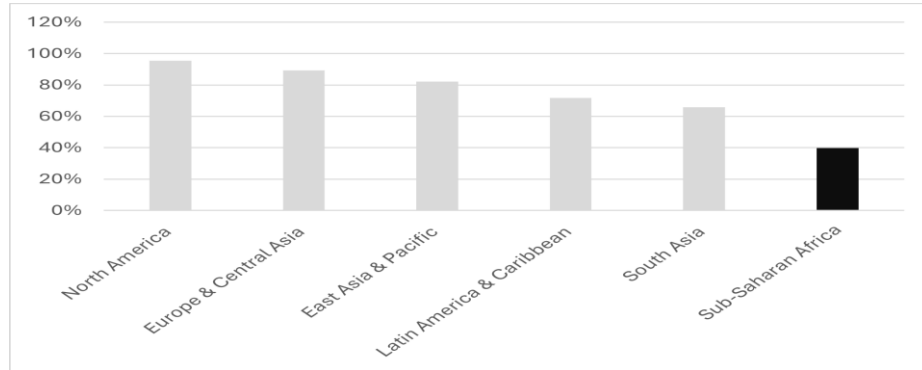
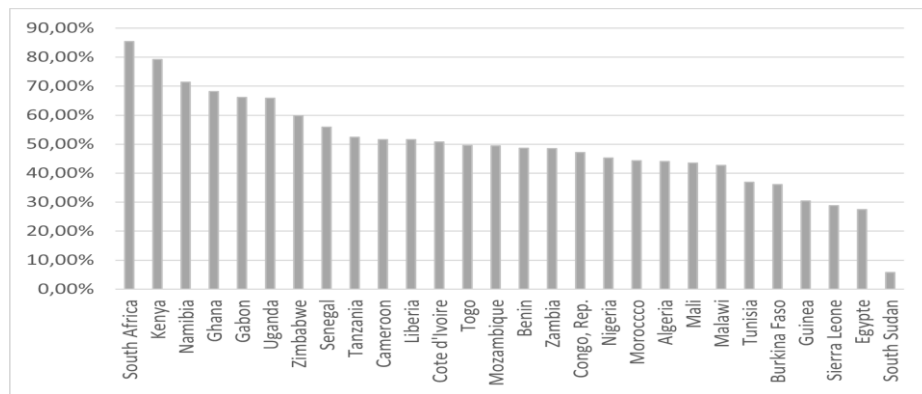**Fig. 1.** The percentage of adult population with bank accounts in the world's continents

Fig. 2. the percentage of adult population with bank accounts in each African country
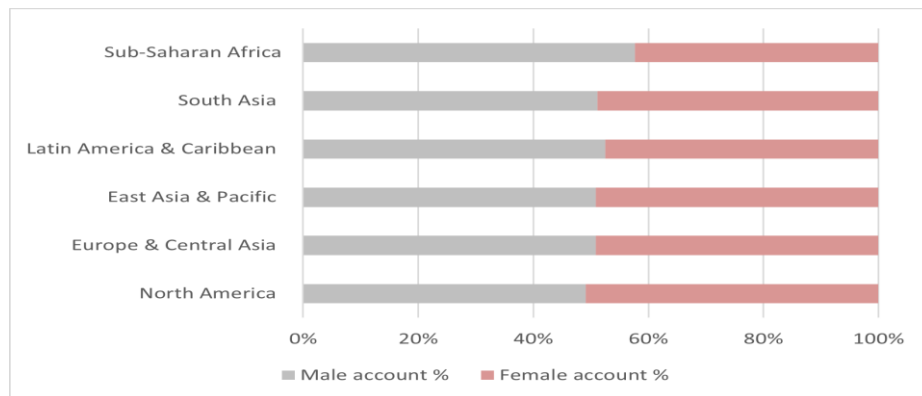

Fig. 3. the percentage of adult population with bank accounts in the world continents based on Gender
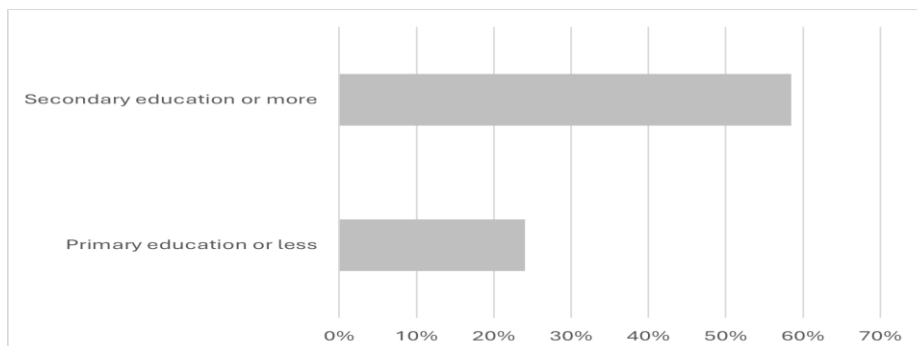
Fig. 4. the percentage of adult population with bank accounts in Africa based on Education
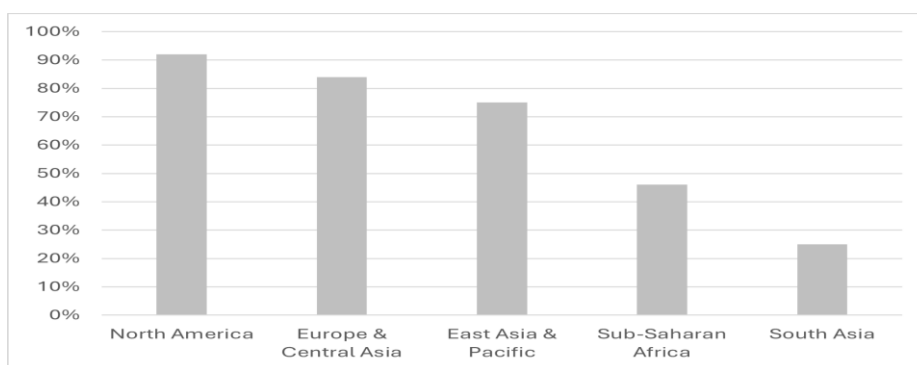

Fig. 5. the percentage of adult population that made at least one digital payment in the world continents
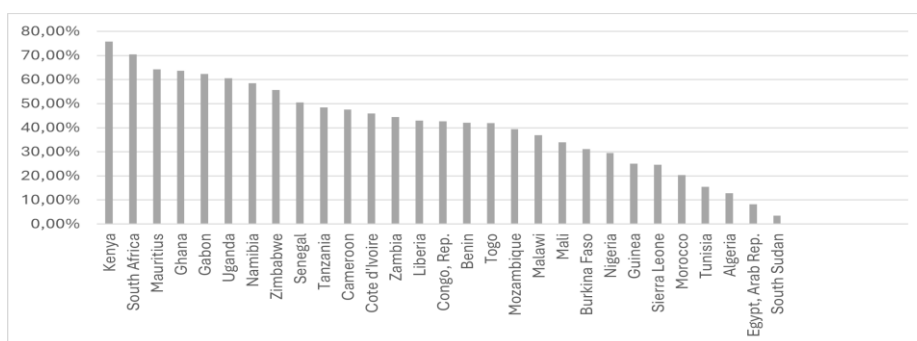

Fig. 6. The percentage of adult population that made at least one digital payment in each African country
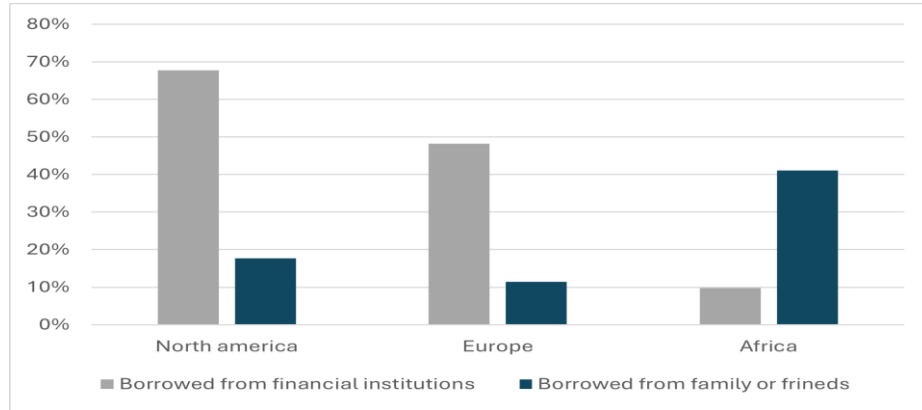
Fig. 7. The borrowing behavior of population in the world continents

4 Blockchain technology for financial inclusion of smallholder farmers in Africa

The preceding section's analysis clearly demonstrates that African countries have attained a relatively low level of financial inclusion. The main features of blockchain technology make it suitable for developing solutions for financial inclusion in Africa. The decentralization feature of blockchain allows network members to access the entire record of financial transactions and enables real-time tracking of the transaction process, the blockchain is immutable and governed by a consensus algorithm, which prevents any manipulation of data, the blockchain uses smart contracts that enable automated transactions. As a result, blockchain can reduce transaction fees and delays by eliminating the need for third-party financial intermediaries, this can help make financial services more accessible and affordable for smallholder farmers. For example, Stellar and Ripple have shown how blockchain can enable fast and secure transactions, these platforms allow instant money transfers at lower fees [16]. Additionally, blockchain can create a reliable digital identity platform to authenticate farmers' identities and document their physical assets, like land titles usable as collateral, and digital assets, such as their economic activity, including credit history and the quality and quantity of agricultural products [17]. This secure and transparent data can encourage financial institutions to provide financial services for smallholder farmers and SMEs in the agricultural supply chain [17]. Blockchain can develop a secure and transparent platform for peer-to-peer microfinancing, allowing farmers to receive loans from lenders [18], smart contracts can determine loan repayment conditions and terms [18]. Due to blockchain, smallholder farmers will not be limited to national financial institutions, they can conduct transactions with any participant in the network since the technology is distributed and decentralized [9]. This enables access to a broader range of products and services in the global financial markets [9]. Blockchain technology can digitize and automate insurance payments using smart contracts, providing higher insurance coverage [19]. For example, Acre Africa is implementing blockchain solutions to a

microinsurance product that protects thousands of small-scale farmers in Kenya from extreme weather events [20].

5   Case study: Twiga foods pilot project in Kenya

Twiga Foods is a Kenyan agritech and logistics company founded in 2014, it connects kiosks, vendors and outlets in urban Nairobi to fruit and vegetable producers in rural Kenya through a mobile-based business-to-business logistics [21].

For farmers, they must register online and submit the requisite information about their farm and the products they produce. The produce is subsequently booked with specific details regarding the harvest, and Twiga issues a purchase order. The commodities are transported to Twiga's collection point after harvesting. The produce is weighed, a receipt is issued, and the farmer is paid within 24 hours of commodity collection via the M-Pesa mobile money platform [22]. For Vendors, they register online, and a Twiga sales representative visits the vendors to register them in the system. The registered vendor can then place their orders directly on Twiga platform. Twiga sends the commodities via its distribution vehicles, the vendors receive the orders within 24 hours of placing the order [22].

In 2017, Twiga Foods has partnered with IBM to implement a blockchain-based microfinancing platform for food vendors in Kenya, allowing them to buy food from Twiga's suppliers [23]. Twiga makes supply chains more effective by eliminating intermediaries, which benefits vendors and farmers [24]. Co-founder of Twiga Foods Grant Brooke stated "Previously, we were focused on helping farmers distribute bananas, tomatoes, onions and potatoes to 2,600 kiosks across Kenya, but we soon realized that we could help them sell even more produce with access to working capital. If the food vendors can sell more, we can distribute more, growing both of our businesses."[25]. The blockchain decentralization feature makes the financing process more transparent for all entities involved. The blockchain is immutable, which helps reduce fraud since no one entity can manipulate the data recorded on the blockchain without the consensus of the whole network. Blockchains also use smart contracts that can be implemented in real time, which has the potential to lower the time required to process and issue a loan [25]. IBM researchers analyzed mobile purchase data and used machine learning to determine creditworthiness [26]. Additionally, blockchain Hyperledger Fabric commands every step of the financing process from application to getting offers to agreeing on the conditions of repayment, the platform provides lenders with the necessary assurance to support loans and repayments for small businesses [26]. The pilot project ran eight weeks and handled over 220 loans, with the average loan at $30, increasing order size by 30% and vendor earnings by 6% [25]. The loans were processed using a mobile device. The terms of the loans were as follows: one percent interest for four days and two percent interest for eight days, a vendor would get an SMS offering loan options once an order was delivered, they would reply to the SMS with their loan choice [25].

6   Blockchain challenges :

Although the potential application of blockchain technology provides a mostly optimistic future, there are still challenges and barriers to their practical implementation. The regulatory frameworks in African countries remain underdeveloped [27], which restricts investment in blockchain projects and creates uncertainty. Furthermore, the lack of infrastructure in rural regions of Africa can limit the adoption of blockchain technology including limited access to electricity and poor internet connectivity [28, 29]. Additionally, blockchain usage requires considerable investments in new hardware and software that can be expensive for smallholder farmers [30], food businesses with sufficient money and IT capacity seem better suited for implementing blockchain [31]. Another barrier to blockchain adoption is the lack of knowledge, African rural farmers have a high illiteracy rate and low digital literacy, which makes it challenging to comprehend and use blockchain technology efficiently. Moreover, there can be significant cultural resistance due to the complexity of blockchain technology and the lack of knowledge of its potential benefits and applications [32].

7   Conclusion :

In conclusion, blockchain technology holds significant potential to increase the financial inclusion of smallholder farmers in Africa. Its decentralization, and transparency features can overcome traditional barriers to the access to financial services. Despite this, several challenges such as limited digital infrastructure, regulatory uncertainty, and the lack of technical competence must be addressed. By overcoming these barriers, blockchain can play a transformative role in connecting African farmers to the global and local food supply chains.

References

1.   Aksoy, M. and A. Isik-Dikmelik, *Are Low Food Prices Pro-poor?—Net Food Buyers and Sellers in Low-Income Countries.* Journal of Rural Mental Health, 2008. **4642**.

2.   Steenwinkel, W.A., *Rural development and external assistance to that sector*, I.S. Arnhem, Editor. 1979: The Netherlands. p. pp. 77–94.

3.   Wiggins, S., *Can the Smallholder Model Deliver Poverty Reduction and Food Security for a Rapidly Growing Population in Africa?* 2009.

4.   Malabo Montpellier Panel, *Mechanized: Transforming Africa's agriculture value chains*. 2018: Dakar, Senegal.

5.   McKinsey Global Institute, *Lions on the Move: The Progress and Potential of African Economies*, M. Company, Editor. 2010: London.

6.   MINAGRI, *Strategic plan for the transformation of agriculture in Rwanda—Phase II (PSTA II)*, M.o.A.a.A. Resources, Editor. 2009.

7. Matt Shakhovskoy and Romit Mehta, *Protecting growing prosperity: Agricultural insurance in the developing world*. 2018. p. 30.

8. Fan, S. and C. Rue, *The Role of Smallholder Farms in a Changing World*, in *The Role of Smallholder Farms in Food and Nutrition Security*, S. Gomez y Paloma, L. Riesgo, and K. Louhichi, Editors. 2020, Springer International Publishing: Cham. p. 13-28.

9. Schuetz, S. and V. Venkatesh, *Blockchain, adoption, and financial inclusion in India: Research opportunities.* International Journal of Information Management, 2020. **52**: p. 101936.

10. Guo, H. and X. Yu, *A survey on blockchain technology and its security.* Blockchain: Research and Applications, 2022. **3**(2): p. 100067.

11. Wang, Q., R. Li, and L. Zhan, *Blockchain technology in the energy sector: From basic research to real world applications.* Computer Science Review, 2021. **39**: p. 100362.

12. Uddin, M.A., et al., *A survey on the adoption of blockchain in IoT: challenges and solutions.* Blockchain: Research and Applications, 2021. **2**(2): p. 100006.

13. Bai, Y., Y. Liu, and W.M. Yeo, *Supply chain finance: What are the challenges in the adoption of blockchain technology?* Journal of Digital Economy, 2022. **1**(3): p. 153-165.

14. Khan, S.N., et al., *Blockchain smart contracts: Applications, challenges, and future trends.* Peer-to-Peer Networking and Applications, 2021. **14**(5): p. 2901-2925.

15. Varghese, G. and L. Viswanathan, *Normative perspectives on financial inclusion: Facts beyond statistics.* Journal of Public Affairs, 2018. **18**(4): p. e1829.

16. Akcora, C.G., Y.R. Gel, and M. Kantarcioglu, *Blockchain networks: Data structures of Bitcoin, Monero, Zcash, Ethereum, Ripple, and Iota.* WIREs Data Mining and Knowledge Discovery, 2022. **12**(1): p. e1436.

17. Tripoli, M. and J. Schmidhuber, *Emerging Opportunities for the Application of Blockchain in the Agri-food Industry.* 2018.

18. Hoque, M.M., T.-F. Kummer, and O. Yigitbasioglu, *How can blockchain-based lending platforms support microcredit activities in developing countries? An empirical validation of its opportunities and challenges.* Technological Forecasting and Social Change, 2024. **203**: p. 123400.

19. Mavilia, R. and R. Pisani, *Blockchain for agricultural sector: The case of South Africa.* African Journal of Science, Technology, Innovation and Development, 2022. **14**(3): p. 845-851.

20. Onder, S., *OPINION: Blockchain can drive financial inclusion and climate resilience*, in *Thomson Reuters* 2022.

21. Nair, R.d. and N. Landani, *Making agricultural value chains more inclusive through technology and innovation.* UNU-WIDER, 2020.

22. Chege, C., et al., *Small and medium enterprises (SMEs) disrupt food systems to deliver healthy diets to urban consumers: Twiga case study*, CIAT, Editor. 2023: Nairobi Kenya. p. 30.

23. Sahoo, S., et al., *Blockchain for sustainable supply chain management: trends and ways forward.* Electronic Commerce Research, 2022.

24. Addison, C., et al., *Opportunities of blockchain for agriculture: : Reader for Brussels Briefing 55*, CTA, Editor. 2019: Wageningen, The Netherlands.

25. Writer, S., *How IBM Is Using Machine Learning & Blockchain*, in *CIO AFRICA*. 2018.

10

26. Maheshwari, H., et al., *Machine Learning And Blockchain: A Promising Future*. 2023. 1-6.

27. Mckenzie, B., *Blockchain and Cryptocurrency in Africa : A comparative summary of the reception and regulation of Blockchain and Cryptocurrency in Africa*. 2018.

28. Gracelin, B. and C. Sophie, *Achieving Universal Energy Access in Africa amid Global Decarbonization*. 2024, Center for Strategic and International Studies (CSIS).

29. United Nations, E.C.f.A., *Digital Infrastructure in Africa*. 2023: Addis Ababa.

30. Saberi, S., et al., *Blockchain technology and its relationships to sustainable supply chain management.* International Journal of Production Research, 2019. **57**(7): p. 2117-2135.

31. Li, K., J.Y. Lee, and A. Gharehgozli, *Blockchain in food supply chains: a literature review and synthesis analysis of platforms, benefits and challenges.* International Journal of Production Research, 2023. **61**(11): p. 3527-3546.

32. Hakak, S., et al., *Securing Smart Cities through Blockchain Technology: Architecture, Requirements, and Challenges.* IEEE Network, 2020. **34**(1): p. 8-14.