Emerging Technologies in Africa: Artificial Intelligence, Blockchain, and Internet of Things Applications and Way Forward

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ABSTRACT

Emerging technologies such as Artificial Intelligence (AI), Blockchain (BCT), and the Internet of Things (IoT) have the potential to accelerate the economic transformation of developing countries. Most developed economies are already taking initiatives for "responsible" implementation of these technologies, such as capacity development, infrastructure enhancement, and establishing governance standards. Similar initiatives in Africa are little known. The literature highlights the potential and opportunities/challenges of implementing emerging technologies. However, the research rarely addresses how to implement such technologies in Africa for sustainable development, and the associated challenges often lead to abandoned solutions in the early stages. This paper explores the application of emerging technologies in Africa to determine the challenges associated with the implementation and derive recommendations for responsible designs. We used the PESTEL-O framework to categorise the identified challenges and risks. The findings reveal a status quo in adopting emerging technology in Africa and provide recommendations for a responsible design of such solutions.

CCS CONCEPTS

• **Social and professional topics**; • **Computing/technology policy**; • **Government technology policy**; • **Government regulations**;

KEYWORDS

Emerging technologies in Africa, AI in Africa, Blockchain in Africa, IoT in Africa, Digital technologies for sustainable development in Africa

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1 INTRODUCTION

Emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain technology (BCT) have the potential to accelerate the economic transformation of developing countries, leapfrogging and leaping forward. These technologies are regarded as frontier technologies that will bring new business models and disrupt organisations [1].

IoT, for example, enables the consolidation of physical objects in an information network ranging from everyday gadgets like smartphones to sophisticated machinery that helps collect data [2], which can later be used for analysis and storage through AI and BCT. IoT applications, such as home automation and wearable devices, are becoming popular, wherein they contribute to energy efficiency (among other advantages), and wearable devices offer autonomous and noninvasive monitoring, contributing to improved functioning and well-being [3]; [4]. The technology is also used in digital governance for environmental sustainability, smart cities, health, transportation, public safety [5], commercial applications, and agricultural supply chain management to increase farming performance [6]; [7].

AI technology comprises machines that utilise and learn from the data to perform human tasks accurately with no or minimum supervision, improving the efficiency and effectiveness of operations and services [8]. AI applications are anticipated to transform governments and societies by solving challenges yet to be addressed by the digital government. For instance, through chatbots, governments can respond to citizen requests and provide timely feedback 24/7 [9]. Also, cities can predict and better manage natural disasters and calamities [10]. Farmers can practice smart farming through machine learning (ML), such as predicting crop diseases and weather forecasting [11]. These applications contribute to sustainable development in communities. Nonetheless, implementing AI technologies faces challenges impeding the technology's acceleration [12].

In comparison, BCT represents a secure way of data handling and is a decentralised digital archive that stores transactions in a list of blocks through cryptography [13]. Moreover, it provides transparency and trustful recording of transaction data, eliminating the need for intermediaries [14]; [15]. Combining the three emerging technologies can maximise their potential and minimise security and trust risks. Ghana has used blockchain technology to manage land administration processes and data [16]. Also, the technology has the potential to be applied to facilitate micro-lending processes for farmers as BCT builds on transparency and new trust levels and cooperation among them [17]. However, the technology also poses challenges, such as the uncertainties related to BCT activities' regulation [18].

Looking into the African continent at a macro level, these technologies have shown the potential to solve community challenges and promote sustainable development goals. For example, African communities use IoT mainly through sensors and smart metres to manage and conserve water in farmlands [19]; [7]. Similarly, data collected from IoT devices, such as in agriculture, is utilised by AI technology to manage crop growth. The agricultural sector in Africa also sees the potential of BCT for tracking the supply chain from its origin to consumption [20]. For example, two companies joined forces in Ethiopia's coffee supply chain to tackle the problem of transparently exporting Ethiopia's unprocessed coffee through blockchain technology [21]. Besides allowing a transparent supply chain, following the process of sifting, roasting, and packaging prized Arabica beans and exporting them to Europe, it also works towards keeping as much of the profits as possible in Ethiopia [22].

Often, these technologies are initiated from the bottom level [23]. Nonetheless, implementing these technologies also needs proper governance in the sustainable solutions' design and development process [24]. However, there are limited governance initiatives for emerging technologies in Africa. There are also inequalities in Africa, such as gender, cultural and linguistic diversity [25]. Therefore, building emerging technologies under these circumstances will widen the digital inclusion gap and hinder the promotion of inclusive, resilient, and sustainable societies [24]. Thus, there is a need for a comprehensive review of emerging technology implementation in Africa to explore the current approaches and propose policy briefs, standards, and regulations for governing the design and use of responsible solutions.

This paper is part of ongoing research examining the adoption and application of emerging technologies in Africa. The paper aims to understand "*What is the status of adopting and using emerging technologies in Africa?*" The question is addressed by examining the potentials, opportunities, and challenges of the three leading emerging technologies presented previously – AI, BCT, and IoT and delving into existing case studies from desk research. The literature findings unveil the limited availability of comprehensive analysis related to emerging technologies in Africa and emphasise the need for further research to a responsible adoption and use of emerging technologies for more resilient, economic, and environmental social good in Africa.

The remainder of the paper is as follows. Section 2 presents the research design used to answer the paper's objective, whereas Section 3 discusses the literature review. Section 4 explores existing applications of AI, BCT, and IoT in Africa by highlighting challenges, and Section 5 proposes recommendations for the sustainable development of emerging technologies. The paper concludes by revealing its limitations and areas for future research in Section 6.

2 METHODOLOGY

The research is based on a systematic literature review to study the emerging technologies landscape in Africa. This approach also aims to guide the future steps of the study, providing a situational background that would mould research instruments (e.g., key informant interviews and in-depth case studies).

The paper explores the implementation of AI, BCT, and the IoT in Africa by collecting secondary data and document analysis. Thus, the systematic literature review and desk research focused on identifying the potential and opportunities of these technologies in Africa. The paper further explored the application of these emerging technologies in Africa by looking into demonstrated, piloted, and implemented areas and pointing out the challenges hindering the implementation. To retrieve this information, we searched for AI, BCT, and IoT-related papers from the scientific and non-scientific databases for the African context. Search engines such as Google Scholar and other academic databases such as ACM digital library, Springer, and IEEE Xplore were used to obtain the required information. The search was narrowed to papers communicating the technologies' potentials, opportunities, and case studies. We used different keywords to retrieve the articles like '*emerging technologies in Africa', 'application of AI/BCT/IoT in Africa', 'Artificial Intelligence/Blockchain/Internet of Things use cases in Africa' and 'AI/Blockchain/IoT opportunities in Africa*'. In addition to searching academic databases, non-academic databases and information from different African countries through websites and portals were also analysed, particularly to identify existing applications of these emerging technologies in Africa. Results showed a limited number of existing use cases/case studies in both scientific and grey literature from Africa.

Once the cases were analysed, the challenges identified were categorised using PESTEL-O analysis. It combines the PESTEL method by Yüksel [26] which stands for "Political, Economical, Sociocultural, Technological, Environmental and Legal", and we also added an Organisational perspective. The categorization seemed the most adequate since several challenges identified fit in the organisational category. Furthermore, the literature analysis showed the organisational impact on the failure/success of the adoption/use of the implementation of emerging technologies [27]. Additionally, future research directions were derived from the challenges to propose the policy implications and recommendations for the responsible adoption and use of AI, BCT, and IoT in Africa.

3 POTENTIALS AND OPPORTUNITIES OF THE AI, BCT, AND IOT IN AFRICA

The advancement of digital government and governance in Africa has led to massive data generation. Also, adopting emerging technologies like IoT contributes to data availability. The IoT technology began with the interconnection of objects and systems and evolved to the second generation that integrated connected things with the web of things [28]. Today, there is an interconnection between social objects, cloud computing, and the future Internet. The IoT can gather data from various connected devices and systems and exchange it via the cloud and the Internet to support decision-making [28]. One of the potentials of IoT relies on its ability to generate data, which is coined to be "big, open, and linked," its quality is often better than traditional data because it is more granular, accurate, heterogeneous, timely, and voluminous [29]. According to Statista's report [30], around 75 billion IoT devices will be used by 2025. Also, every connected individual, through IoT gadgets, for example, shall partake in a data exchange every 18 seconds, generating more than 90 zettabytes of data [31]. Such advancement through IoT creates potential in organizations, such as collecting real-time data, analysing historical data, and enhancing service performance [29]. Also, connecting physical and digital objects remotely contributes to sustainable cities, like the emergence of smart cities [6] and climate change mitigation [32].

African countries have already started investing in IoT decades ago. For instance, South Africa and Kenya have been leading the investments in the region on infrastructure related to machine-to-machine or M2M solutions and IoT subset technology [6]; [28]. Besides the technical aspects of IoT, this emerging technology also provides solutions that address several societal challenges in Africa. For example, in healthcare, IoT can help in areas like tracking medical items and monitoring the health of older adults at home. In transportation, IoT can help to avoid accidents [6]. IoT can also deliver more efficient services using fewer resources and amplify the impact with comparable levels of existing resources [33]. Additionally, integrating IoT with other technologies, such as AI and BCT, can deliver more innovative approaches to obtain accurate measurements that define transactions and performance attributes [34]. Therefore, exploring these technologies in the African context is important.

Regarding AI, the technology can potentially increase the efficiency and effectiveness of public services. Currently, the potential of AI is realised in different sectors, such as agriculture to promote smart farming [35], the health sector to improve services and provide early detection of diseases [36] and local government to encourage citizen engagement and provide timely feedback [37]. There are ongoing initiatives to support AI implementation in Africa, such as capacity building (e.g., see [38] and [39]). Also, the African Union Development Agency [40] has established a continental strategy to accelerate the adoption of AI. Still, the technology application faces some challenges. According to the Government AI Readiness Index 2022 [41], there needs to be more infrastructure to accommodate digital transformation and adoption of AI in Africa. The report also highlighted a need for AI-related regulations, enforcement, and policy to govern the design and use of AI solutions. Several researchers also observed this. However, limited research addresses the matter. Adopting strategies and standards established in developed African countries can be challenging due to the contextual differences. Gimpel and McBride [37] emphasised the need for more empirical research that studies how AI adoption and its usage are influenced by context. Therefore, there is a need to explore the technology implementation in the continent.

The potential and opportunities of BCT started initially in economics and finance. Currently, technology has a multitude of functionalities and approaches besides these fields. The increase in practical use cases and experimentation is critical to moving beyond the hype and the speculation surrounding the technology [42]. BCT is now applied in agriculture, health, land registry, or fintech, where immutability, traceability, decentralized structure, and trust relationships are explored [43]. Cagigas et al. [43] explored blockchain's benefits and risks to governments, civil servants, and citizens from the literature. Their study identified benefits such as increased efficiency, traceability, and coordination. Also, risks like unavailability of governance standards, insufficient funds, cultural shifts, and lack of trust in the technology can affect its implementation.

Researchers argued that BCT has a higher value proposition for the developing world and, more specifically, can solve many problems affecting African countries [44]; [15]. This is due to the main characteristics of the technology: distribution, immutability, and automation, which can establish a solid base for economic growth and social progress in a challenging context [14]. For example, cryptocurrencies are especially advantageous in African countries with highly volatile currencies and high inflation [45]. Also, the technology provides transparency and traceability features that monitor the agriculture supply chain and improve the agricultural service (see examples in [21] and [46]). Additionally, Ameyaw and de Vries [16] demonstrated using BCT to reduce corruption and errors in the land acquisition process and other registries. The GIZ report [14] shows how BCT can echo a feeling of community across the continent and cultivate cross-continental alliances. Still, the technology is not fully explored in Africa. It is surrounded by distrust and misinformation from a false understanding of the technology and a lack of regulations [47]; [48].

From the identified potentials of the technologies in Africa, we further identified the application areas in the subsequent section.

4 APPLICATIONS OF AI, BCT, AND IOT IN AFRICA

A diversity of sectors in Africa are adopting and implementing AI, BCT, and IoT to solve community problems. In this section, a selection of examples of these technologies' application in Africa is presented, highlighting the identified enablers and barriers to successful implementation.

4.1 IoT applications in Africa

IoT in water management. Since the 1990s, access to clean and sustainable water has been an ongoing issue for Africa, especially in the sub-Saharan region, where more than 90% rely on surface water only, and almost 80% still have no access to improved water sources in rural areas [49]. Several African countries have applied IoT to manage water systems to address this. In Rwanda, sensors are used to track the performance of water pumps, and in Niger, smart meters are utilised for distributing safe and potable water to underserved communities [19]; [7]. IoT sensors are also implemented to assist small-scale farmers in managing water and agricultural aggregators in South Africa. Sensor nodes are utilised for conserving water in tomato farms in Senegal [7]. Tracking devices and gateways are also used in fisheries in Ghana to ensure that the water's oxygen, temperature, and pH levels are safe [19].

IoT in environmental sustainability. As an agricultural region, most of the African population, especially in rural areas, relies on farming for their income, but the region still ranks low on food security globally [50]. Sustainable energy is also an ongoing issue, especially in the sub-Saharan region, which only generates 68 gigawatts of power capacity [51]. Hence, African countries also need to address these issues of environmental sustainability, food security, and productivity, which is why IoT was also explored for this endeavour [33]. Rwanda uses IoT for early climate warning, specifically through sensors and open-source data, which gathers real-time data on soil humidity, temperature, and moisture [52]. IoT also aids waste management, such as Togo's sensor-enabled smart trash bins and Nairobi's waste management trucks [19].

Meanwhile, sensors can also help ensure power plants are more efficient, such as the project implemented by the United Nations Industrial Development Organization (UNIDO) and the Japan International Cooperation Agency (JICA) with the Kenya Electricity Generating Company that extracts data from the turbines and generators to detect their vibrations and temperature [53]. South Africa also uses drones for active wildlife surveillance [54]. Yet, using these technologies requires guidance and standards to ensure sustainable development.

IoT in healthcare and social services. The African region is also highly vulnerable to several non-communicable and tropical diseases. Many African countries, especially in the sub-Saharan region, face issues that impede citizens' access to universal healthcare. IoT can also help make more informed decisions for health workers while delivering health services [33]. For example, South Africa uses IoT to collect patient information [55]. The Rwandan government has partnered with the American company Zipline to use drones for transporting blood and medical supplies to rural hospitals [56]. SystemOne and Telecom26 have been operating in 19 African countries, utilising diagnostic software to test infectious diseases [57]. Mobile phone data and call records were also instrumental in tracking people's movements during the Ebola outbreak in West Africa [32]. Electronic dispensing tools also assist pharmaceutical experts in Namibia in gathering patient data that would be useful in dispensing medicines [58].

4.2 AI applications in Africa

Since introducing AI and its related technologies, researchers and practitioners have implemented it to solve community challenges. The health sector is among the areas where several use cases are proposed to predict diseases at early stages and improve the provision of health services. For example, Bellemo et al. [36] demonstrated using AI models to detect referable diabetic retinopathy, vision-threatening diabetic retinopathy, and diabetic macular oedema in Zambia. However, the usability model was hindered by insufficient infrastructure like unreliable telecommunication networks and limited high computing resources. Regarding improving the provision of health services, AI practitioners from Rwanda introduced AI-powered tools to minimise diagnostic errors resulting from limited doctors attending to many patients [59]. In Tanzania, Afya Intelligence solutions provides a chatbot to connect suppliers and pharmacies, allowing users to interact with virtual doctors to predict their diseases and recommend further actions [60]. Similar solutions are used in Rwanda to improve health care [61]. Still, their implementation is challenged by a lack of user trust, data privacy, and regulation for AI in health [12].

Furthermore, AI is widely applied in agriculture in Africa. Aworka et al. [11] demonstrated the potential of machine learning in predicting crop yield to improve food security in communities. Although the developed model illustrated accuracy in predicting crop yield in East African countries, its performance, if implemented, is affected by the poor availability of agricultural data used to train the model.

AI is also used to improve public service in government and cities. Mbaza Chatbot from Rwanda was launched to reduce the burden of incoming calls from citizens and provide citizens with reliable information related to COVID-19 information, thus aiming to deliver information fast to citizens [37]. The chatbot was launched with less bureaucracy since there was strong support from the government. However, there was no thorough assessment of whether AI was a solution. As a result, the solution encountered challenges such as the inability to deliver in the form of various local languages, weak infrastructure, insufficient data, a lack of AI knowledge and expertise, unclear guidance to apply data privacy law, and a lack of awareness to citizens. As a result, the chatbot is not fully implemented in the Rwandan government.

Additionally, AI is used in urban planning in Africa. For instance, The eThekwini Municipality in South Africa, in collaboration with the United Nations Innovation Technology Accelerator for Cities in Hamburg (UNITAC Hamburg), implemented a Building and Establishment Automated Mapper (BEAM) project [62]. The project provided a tool that uses machine learning to identify informal settlements and structures on satellite imagery and/or aerial photography, drastically speeding up the identification process to improve land monitoring [62]. Still, data challenges within the informal settlements' space, which compromises strategic decision-making and limited expertise, are slowing the implementation.

While researchers and practitioners demonstrate the potential of AI, its implementation in a specific field at the community level is still scarce. Most of the projects are problem-driven and originate from the bottom level. As a result, it becomes difficult to scale such projects, especially due to the lack of support from top management and unclear standards and regulations to guide the implementation.

4.3 BCT applications in Africa

Blockchain in the health sector. There are few forms of BCT implementation in healthcare in Africa regardless of the propositions made by several studies on how the technology can potentially solve pertinent issues such as missing files or records, and a lack of information sharing between healthcare providers constitute an obstacle to the quality of the service provided [63]. In Kenya, the Medixus group allows health practitioners to collaborate via Electronic Medical Records (EMR) platform that uses BCT to ensure patient data is available and thus contribute to improving the quality of clinical services through informed decisions [64]. Also, information security represents an essential aspect of making advances in adopting BCT in the health system, and hospitals should integrate legislation ensuring the security, privacy, and integrity of sensitive healthcare data. Focusing on the issues related to privacy and security of the information, Kamau and others [65] stressed that encryption in BCT is crucial for preserving patients' privacy, especially when patients' data moves between stakeholders and institutions, and the case study in Tanzania focusing on data storage security found that using a Hyperledger Fabric blockchain can be a way of providing secured data storage while having a high performance [66].

Blockchain in land management. The technology can monitor and manage land in cities. For example, in Rwanda, the Ubutaka app [67] prevents the double selling of land and the forgery of signatures by recording key authorizations and approvals on the blockchain. The integration of the system into the National ID Agency (NIDA) and the Land Administration Information System (LAIS) allows buyers and sellers to make a single visit to the notary office. Thus, there is increased efficiency, security, and accessibility of land transfers by voluntary sale [68]. In Ghana, the land acquisition process faces many challenges, including double sales of land, difficulty in getting reliable land information, and issuance of unreliable land documents to land purchasers; thus, blockchain technology is introduced [16]. Through BCT, land transactions can occur without recurring to intermediaries, eliminating unofficial charges and increasing transparency and trust in land processes.

Blockchain in agriculture has the potential to become a game-changer for supply chains since its unique features can diminish supply chain inefficiencies, boost trust among stakeholders (i.e., farmers, primary processors, traders, product manufacturers, distributors, retailers, and consumers) and reduce associated costs [20]. The “Blockchain for Agrifood” project in South Africa used BCT to track the wine production supply chain, ensuring strong traceability and avoiding specifying false geographical regions or ingredients and modifications [69]. Another pilot program was launched with Uganda-based coffee and a Denver-based (USA) coffee roaster to bring more transparency and efficiency to the coffee supply chain [70]. More blockchain-based agricultural solutions exist in Kenya, Ghana, and Ethiopia, and these can also be related to proof of ownership, collaborative platforms between farmers and agricultural financing tools [18]. However, most projects are implemented without clear regulations and policies, making them difficult to scale.

Blockchain in payment. The African continent is progressively adopting mobile cash and virtual currencies (CBDC), some countries more than others [71]. Fiat-to-crypto transactions occur daily with peer-to-peer (P2P) Networks and Payment Agents, such as DafriXchange and DafriBank [71]. This increasing interest in cryptocurrencies is seen, especially in Sub-Saharan Africa, in countries like Nigeria, South Africa, Kenya, and Ghana [45]. However, much mistrust remains surrounding this technology because of the absence of clear regulations and the hesitation it faces by African governments due to a lack of understanding of the technology and the fear of facilitating laundering money activities [71]. Thus, there is a need for the continent and countries to derive regulations and standards for BCT payment and CBDC.

5 CHALLENGES OF AI, BCT, AND IOT IMPLEMENTATIONS IN AFRICA

Emerging technologies like AI, BCT, and IoT can benefit Africa significantly. However, the region’s adoption and implementation of these technologies face common challenges, as summarised in Table 1. The challenges are categorized based on the PESTEL-O analysis.

Political challenges. Most countries in the region observe instability in their political and governance landscapes, making it challenging to organise sustainable projects such as those involving AI, BCT, and IoT [72]; [14]; [23]. Failure to support these technology from leaders hinders its implementation.

Economic challenges. AI, BCT, and IoT face economic challenges. Economic and financial factors have been an obvious impairment for the digital government in Africa. Economic and financial challenges continue to impede innovation and emerging technology adoption. One of the main difficulties resides in accessing and securing funding for projects and initiatives. Usually, funding comes with a set of conditions that are not easy to meet. Also, the high cost of the internet acts as a barrier to end users benefiting from existing solutions.

Socio-cultural challenges. Experts cited that the high level of illiteracy in the region is still an ongoing obstacle to the diffusion of technologies [12]. Thus, this also leads to a lack of skills and capabilities required to deal with these technologies [18]; [15]; [37]. Besides the education and skills of users, these technologies still face some scepticism from potential users, leading to low trust [6]; [12].

Technical challenges. Technical considerations are another critical aspect of implementing AI, BCT, and IoT. Most countries in the region still face problems with unreliable sources of electricity as well as accessibility issues with the internet connection being too expensive or nonexistent, especially in rural communities [33]; [23]. Most connections also work through satellites, and their speed is very limited. Consequently, data like those stored in the blockchain cannot keep up with the needed synchronisation [66]. Also, issues related to data privacy are challenging IoT and AI technologies.

Additionally, implementing these technologies in legacy systems is expensive and can create difficulty in sharing and exchanging data. Moreover, IoT encompasses diverse technologies, applications, and devices with no standard covering all types and multiple competing standards, even within device classes. Developed countries dominate hardware manufacturing, and standardisation processes for hardware, software, and communication protocols are underrepresented in Africa [73].

Environmental challenges. Given insufficient power generation capacity and distribution architecture in most African countries, energy efficiency is crucial for enabling significant IoT expansion [73]. There is also a significant gap in energy and telecommunication infrastructures between urban and rural cities [18].

Legal challenges. Researchers also stressed that the African region is facing some legal challenges as most countries still lack policies that discuss the proper management of data [58]; [12]. These policy frameworks must be able to consider concerns on deluge, trust, and scalability, among others, since these are important considerations for these technologies. Furthermore, implementing these technologies requires regulation and governance of the technology adoption and usage; still, such governance is lacking. Likewise, since the technology is expected to bring together actors from different sectors and countries, it requires clearer safeguards for blockchain users and their data [15]; [18].

Organisational challenges. Lastly, several organisational challenges are also seen in IoT implementations in Africa. Most existing strategies pertaining to the digital transformation of African

Table 1: Challenges of implementing emerging technologies (AI, BCT, and IoT) in Africa

Categories based on PESTEL-O	Artificial Intelligence	Blockchain	Internet of Things
Political challenges	Lack of support from political leaders [12]	Hesitation and lack of support from political leaders [74] Unavailability of blockchain policies [75]	Political instability [72]
Economic challenges	Limited funds to support AI implementation [23]; [37]	Volatility in prices of cryptocurrencies [45]	Poor financial viability of governments to invest in IoT [76]
Socio-cultural challenges	Lack of trust [37]	Lack of skills and capabilities of users [18] Risk-averse attitudes associated with BCT [75]	High level of illiteracy, including digital [6]; [76] Low trust in technology [76]
Technical challenges	Weak infrastructure [23]; [12]	Poor infrastructure to support blockchain [75]	Unreliable power supply and unaffordability or absence of broadband connectivity [33]
	Lack of locally trained models [23]; [12]	Insufficient interoperability across sectors and industries [14]	Security issues [6]
			Difficulties of legacy devices [73] Lack of standards and interoperability for IoT devices [73]
Environmental challenges		Energy consumption and carbon emissions [45]	Need for a more efficient and sustainable energy source [73]
Legal challenges	Limited data protection and privacy regulations [36] Lack of legal frameworks to govern AI [12]	Lack of clear regulations for cryptocurrencies [15]; [45]	Lack of policy frameworks on data management [58]
Organisational challenges	Lack of AI strategy [23]	Absence of technical skills to manage BCT [15]; [75]	Multi-sectoral collaboration in financing and developing IoT projects and regional coordination [73]
	Limited talents in organisations [37]	Weak institutions [75]	Lack of strategies [72]
			Lack of skilled manpower, especially local talents, for IoT implementation [34]

countries are still in their early stages, such as The Digital Transformation Strategy for Africa for 2020-2030. While these policies are vital in harmonising the strategies across African countries, they tend to contribute to delays in agreement and coordination [73]. Many African countries, especially in the sub-Saharan region, face a shortage of skilled manpower needed to deploy the technologies [44]; [37].

6 DISCUSSION AND CONCLUSION

In conclusion, adopting Emerging technologies such as AI, BCT, and IoT in Africa holds promises. It contributes to socio-economic development and to leapfrog the digital transformation development stages. The desk review showed a significant change in how African countries approach and integrate these technologies into various sectors, ranging from healthcare and agriculture to education. While challenges such as the lack of infrastructure as well as the absence of laws and regulations are persistent, the potential benefits are observed. Through such technologies, societies can build resilient and inclusive communities, contributing to sustainable development.

This theoretical paper explores the status of emerging technologies in Africa, particularly AI, BCT, and IoT. We explored the opportunities and potentials of the technologies in Africa, reviewed existing case studies, and determined the challenges of the technologies in Africa. Findings showed limited literature about the emerging Tech adoption in the continent. Also, existing literature adopted a techno-centered perspective focusing on the potentials and possible challenges of the technologies. Moreover, available case studies in Africa communicate the potential of technologies rather than identifying challenges or lessons learned to support other sectors in the continent in implementing the technologies. It is worth noting that the adoption of Emerging Technologies in Africa should be accompanied by Governance standards and regulations with a strong emphasis on ethics, data privacy and security to guide the design and implementation of technologies in the African continent and to ensure more inclusive benefits to all segments of the society. More effort should be made to reduce the digital gap and ensure that rural areas and marginalized communities are not left behind in adopting emerging technologies.

We highlighted the status quo of emerging technologies in this paper and proposed the need for comprehensive empirical research in AI, IoT and blockchain for Africa. Such studies should explore the experienced benefits and challenges of the technologies, scrutinize available governance, policies, and regulations to support the implementations and evaluate whether these technologies are deployed responsibly. In the next steps, we will conduct a situational analysis using a survey exploring the technologies, such as who plan, design, and use emerging technologies for sustainable development. This will be followed by a qualitative study based on interviewing experts who participated in projects implementing emerging technologies on the continent. Findings from the situational analysis will contribute to establishing recommendations for deploying AI, BCT, and IoT in Africa for resilient, inclusive, and sustainable cities.

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