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Emerging Technologies in Africa: Evolution, Diffusion, & Adoption

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ABSTRACT

This study examines the evolution, diffusion, acceptance, and uptake of five emerging technologies in Africa namely: Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G and Data Infrastructure, and Clean Energy or Climate Technologies. Drawing on relevant literature, theoretical frameworks, and empirical case studies, the research analyzes how these technologies are reshaping socio-economic, institutional, and infrastructural landscapes across the continent. The study adopts a multidisciplinary analytical framework, including the Diffusion of Innovations Theory, Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, Innovation Systems Theory, Socio-Technical Systems Theory, and Actor–Network Theory to explain adoption patterns and identify barriers to scalability and sustainability. Findings reveal that these emerging technologies hold substantial promise for advancing financial inclusion, digital governance, energy access, and connectivity. However, adoption and diffusion remain uneven due to persistent infrastructural deficiencies, fragmented regulations, limited technical expertise, and socio-economic disparities. The study concludes that Africa’s technological transformation is at a pivotal juncture. Progress depends not merely on technological deployment but on fostering adaptive governance, strengthening institutional capacity, and promoting inclusive digital ecosystems that respond to local realities. The study recommends the harmonization of regulatory frameworks, investment in capacity-building, inclusive technology deployment strategies, and localized innovation models to promote sustainable, context-sensitive, and broad-based technological advancement that is crucial in ensuring that emerging technologies drive equitable growth rather than deepen existing divides across Africa.

Keywords: Emerging Technologies, Africa, Artificial Intelligence, FinTech, Blockchain, 5G, Clean Energy, Diffusion, Adoption, Digital Transformation

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1. INTRODUCTION

The 21st century has witnessed the accelerated emergence and diffusion of transformative technologies that are redefining economic structures, governance systems, and social interactions across the globe. Emerging technologies such as Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G and Data Infrastructure, and Clean Energy Innovations represent not only the future of global development but also a critical determinant of Africa's socio-economic trajectory (World Bank, 2023). These technologies hold significant potential to address long-standing challenges such as financial exclusion, inadequate infrastructure, limited access to quality healthcare, energy poverty, and educational disparities (UNCTAD, 2022). However, their evolution and integration across African economies have been uneven, influenced by institutional capacities, policy environments, human capital, and socio-cultural factors.

In the African context, emerging technologies have become both an opportunity and a challenge. On one hand, they have catalyzed new business models, expanded access to essential services, and attracted substantial foreign and domestic investments. On the other hand, their diffusion has been hindered by structural weaknesses such as limited digital infrastructure, high costs of connectivity, low digital literacy, and inadequate regulatory coherence (GSMA, 2023). For instance, the rapid expansion of mobile money systems such as M-Pesa in Kenya demonstrates the transformative capacity of FinTech in promoting financial inclusion (Jack & Suri, 2016). Conversely, technologies such as AI and 5G continue to face adoption bottlenecks due to infrastructural deficits, high deployment costs, and limited indigenous innovation capacity (Oxford Insights, 2024).

The study of emerging technologies in Africa must therefore be situated within the theoretical and practical understanding of how innovations evolve, diffuse, and become institutionalized. Theories such as Rogers' (2003) Diffusion of Innovations (DOI), Davis' (1989) Technology Acceptance Model (TAM), and Venkatesh et al.'s (2003) Unified Theory of Acceptance and Use of Technology (UTAUT) offer explanatory frameworks for understanding user adoption and institutional readiness. Complementary perspectives such as Innovation Systems Theory (Freeman, 1987; Lundvall, 1992), Socio-Technical Systems Theory (Trist & Emery, 1951), and Actor-Network Theory (Latour, 2005) extend this analysis by emphasizing systemic interactions, human-technology relationships, and contextual adaptation processes. Applying these frameworks to Africa provides a holistic view of how emerging technologies evolve within socio-economic and cultural ecosystems that differ significantly from those of industrialized nations.

The uneven pace of adoption of emerging technologies across the continent reflects deeper systemic inequalities and the varying capacities of states and private actors to leverage technological advancement for inclusive development. While countries such as Nigeria, Kenya and South Africa have made significant progress in FinTech, AI, and renewable energy applications, others continue to lag behind due to weak policy frameworks, inadequate financing, and insufficient investment in digital and technical education (IRENA, 2022; World Bank, 2023). Thus, understanding the diffusion and acceptance of these technologies requires analyzing both enabling factors such as policy coherence, infrastructure development, and innovation ecosystems and constraints including affordability, governance, and social trust (UNCTAD, 2022). This study explores the evolution, diffusion, acceptance, and uptake of five key emerging technologies: Artificial Intelligence, FinTech, Blockchain, 5G Infrastructure, and Clean Energy across Africa.

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It applies interdisciplinary theoretical frameworks to explain the dynamics shaping their development and adoption. The analysis further examines the usefulness, challenges, and policy implications of these technologies while offering strategic recommendations for stakeholders in government, academia, and industry. Ultimately, the study seeks to contribute to the discourse on Africa's digital transformation by emphasizing the need for contextually grounded, inclusive, and sustainable technological innovation.

1.1 Defining Key Concepts

Emerging technologies refer to novel and rapidly evolving innovations that hold the potential to disrupt or significantly improve socio-economic systems (Rotolo et al., 2015). Evolution captures the stages through which technologies mature from concept to widespread use. Diffusion describes how innovations spread within social systems (Rogers, 2003), while adoption refers to individual or institutional acceptance and use. Together, these processes shape the extent to which emerging technologies contribute to Africa's digital transformation and inclusive growth (GSMA, 2023).

2. LITERATURE REVIEW

Emerging technologies such as Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G Infrastructure, and Clean Energy are transforming socio-economic landscapes globally. In Africa, these technologies have demonstrated potential to catalyze economic inclusion, enhance public service delivery, and support sustainable development goals (UNCTAD, 2022; World Bank, 2023). However, their adoption and diffusion remain uneven, influenced by contextual factors such as infrastructure, governance, and local innovation ecosystems. This review synthesizes scholarly perspectives and empirical evidence on the evolution, diffusion, and adoption of these five technologies within the African context.

AI has evolved from symbolic to connectionist models, enabling machine learning applications in agriculture, healthcare, and language technologies. Studies show Africa's AI adoption is propelled by localized initiatives such as the Masakhane project, which develops natural language processing tools for African languages (Niyirora, 2021). Despite these advances, challenges persist in data quality, digital infrastructure, and governance frameworks (Oxford Insights, 2024). Research indicates that ethical AI development in Africa requires integrating local contexts and cultural values into global standards (World Bank, 2023). FinTech represents one of Africa's most successful technological revolutions. The diffusion of mobile money services such as M-Pesa in Kenya has expanded financial inclusion and fostered micro-entrepreneurship (Jack & Suri, 2016).

The growth of payment gateways like Flutterwave and Paystack further exemplifies innovation driven financial integration across borders (GSMA, 2023). However, empirical studies highlight ongoing challenges regulatory fragmentation, cybersecurity threats, and persistent exclusion in rural populations (UNCTAD, 2022). Blockchain technology has been applied in diverse African sectors, including land registration, supply chain traceability, and digital currencies. Case studies such as Nigeria's eNaira and Ghana's Bitland reveal its promise for enhancing transparency and efficiency (CBN, 2021). Yet, uptake remains limited due to regulatory ambiguity, technical complexity, and low literacy levels (Chainalysis, 2024). Scholars argue for regulatory sandboxes and institutional capacity building to ensure responsible blockchain innovation (UNCTAD, 2022).



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The evolution of 5G infrastructure offers transformative potential for Africa's digital economy, enabling telemedicine, smart agriculture, and connected industries. Reports from GSMA (2023) indicate that while deployment is expanding in South Africa, Kenya, and Nigeria, cost barriers and spectrum management challenges impede wider diffusion. Research underscores the need for harmonized policies and investment in data centers to improve network reliability and affordability (World Bank, 2023).

Clean energy innovations, especially decentralized solar and mini-grid systems are crucial for Africa's energy transition. Studies from IRENA (2022) and the World Bank (2023) highlight the success of pay-as-you-go solar systems in East Africa, which integrate mobile payment technologies for accessibility. Nevertheless, scaling challenges persist due to high upfront costs, maintenance limitations, and inadequate financing structures. Empirical research demonstrates significant progress but persistent asymmetries in adoption patterns. AI and FinTech are leading in terms of user adoption and policy support, whereas blockchain and 5G adoption are constrained by infrastructure and regulation (UNCTAD, 2022). Studies reveal that success factors include perceived utility, affordability, and government support (GSMA, 2023). Conversely, low literacy, inadequate infrastructure, and insufficient research capacity remain critical barriers. Evidence suggests that the most successful technologies, such as M-Pesa and decentralized solar grids, combine technological innovation with social inclusion and local adaptation (Jack & Suri, 2016; IRENA, 2022).

Despite growing interest, several research gaps persist. Few longitudinal studies evaluate the long-term socio-economic effects of emerging technologies across African contexts. There is limited understanding of how local innovation ecosystems influence diffusion and sustainability (Oxford Insights, 2024). Moreover, the intersection between gender, inclusion, and technological access remains under-explored. Future research must adopt comparative, interdisciplinary approaches to assess not only adoption rates but also societal impacts. Africa's digital transformation is shaped by its unique socio-economic and infrastructural realities. Unlike advanced economies, where emerging technologies evolve within robust institutional systems, African diffusion patterns depend heavily on mobile infrastructure, informal innovation, and public-private collaboration (World Bank, 2023).

Contextualizing adoption within this landscape underscores the importance of localized design, affordability, and inclusive policy frameworks. The continent's youthful population and expanding digital literacy present a strong foundation for scaling these technologies toward achieving Agenda 2063 and the Sustainable Development Goals (UNCTAD, 2022). The review reveals that emerging technologies in Africa are evolving rapidly, though unevenly, across sectors. Their successful adoption depends on enabling ecosystems that combine innovation, regulation, and inclusivity. Future directions must emphasize capacity building, localization, and ethical governance to ensure that technological transformation translates into equitable socio-economic progress across the continent.

3. EVOLUTION, DIFFUSION, ACCEPTANCE AND UPTAKE OF EMERGING TECHNOLOGIES IN AFRICA

3.1 Evolution

The evolution and diffusion of emerging technologies across Africa represent a transformative phase in the continent's socio-economic development trajectory. Technologies such as Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G Infrastructure, and Clean Energy are reshaping industries, governance, and social



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interactions. Their spread, however, is not uniform rather, it reflects Africa's unique political, infrastructural, and socio-cultural contexts (World Bank, 2023; UNCTAD, 2022). Understanding the evolution, diffusion, acceptance, and uptake of these technologies provides insight into how innovation ecosystems function and how policy, education, and infrastructure shape technological progress across the continent.

The evolution of emerging technologies in Africa has been characterized by adaptation, localization, and incremental innovation rather than radical invention. In the FinTech sector, Africa's evolution began with the rapid rise of mobile money in the early 2000s, most notably with Kenya's M-Pesa, which demonstrated that digital finance could succeed even in low-income and low-literacy environments (Jack & Suri, 2016). Since then, FinTech ecosystems in Nigeria, Ghana, and South Africa have matured through venture capital support, government sandboxes, and cross-border collaboration (GSMA, 2023).

Again, the evolution of Artificial Intelligence (AI) has been driven by localized initiatives focusing on language processing, agriculture, and healthcare. Projects such as Masakhane and Deep Learning Indaba have catalyzed the development of African-centered AI models that address local linguistic and socio-economic realities (Niyirora, 2021; Oxford Insights, 2024). Similarly, Blockchain technology evolved from early cryptocurrency experiments to governance-focused applications like Ghana's Bitland for land registry and Nigeria's eNaira (CBN, 2021). The evolution of 5G infrastructure reflects a convergence of public-private investment and regional policy initiatives. Early deployments in South Africa and Kenya illustrate Africa's gradual entry into the high-speed data era, though challenges such as affordability and coverage persist (GSMA, 2023). Finally, Clean Energy technologies have evolved through decentralized innovation—solar mini-grids, pay-as-you-go models, and hybrid renewable systems—reflecting Africa's pragmatic approach to energy access and sustainability (IRENA, 2022).

3.2 Diffusion

The diffusion of these technologies follows distinct patterns influenced by socio-economic disparities, institutional readiness, and market incentives. According to Rogers' (2003) Diffusion of Innovations Theory, adoption depends on five key factors: relative advantage, compatibility, complexity, trialability, and observability. In Africa, these determinants are shaped by income levels, infrastructure access, and trust in digital systems. For instance, mobile money diffused rapidly due to its compatibility with informal economies and its visible benefits in daily transactions (Jack & Suri, 2016). By contrast, the diffusion of blockchain and AI has been slower, limited by data infrastructure gaps, high initial costs, and regulatory uncertainty (UNCTAD, 2022). Regional variations also shape diffusion rates. East Africa leads in FinTech and clean energy adoption, West Africa is advancing in blockchain experimentation, while Southern Africa drives 5G deployment (World Bank, 2023). Institutional frameworks, including innovation hubs and digital literacy initiatives, facilitate diffusion by bridging policy and practice. This demonstrates that technological diffusion in Africa is both social and systemic—driven as much by community networks and public trust as by market forces.

3.3 Acceptance

The acceptance of emerging technologies in Africa is deeply intertwined with perceptions of utility, accessibility, and trust. The Technology Acceptance Model (Davis, 1989) and Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003) offer useful insights into user behavior. Studies show that the perceived usefulness of FinTech solutions especially in enabling quick and affordable transactions strongly predicts user adoption



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across countries like Nigeria and Kenya (GSMA, 2023). Similarly, the acceptance of AI tools depends on their perceived relevance and cultural fit. For instance, users are more likely to adopt AI-based chatbots when they support local languages or solve context-specific challenges, such as agricultural advisory or healthcare diagnostics (Niyirora, 2021).

Social influence and facilitating conditions also affect acceptance. Governments and influential organizations play a key role in legitimizing new technologies, as seen in state-backed blockchain and 5G projects (CBN, 2021). However, acceptance is often limited by digital literacy gaps, affordability constraints, and mistrust of data privacy mechanisms (UNCTAD, 2022). Therefore, technological acceptance in Africa must be understood as a socially negotiated process, influenced by economic, cultural, and institutional trust factors.

3.4 Uptake

The uptake of emerging technologies refers to the actual implementation and sustained use of innovations within social and economic systems. Uptake in Africa often depends on three interrelated conditions: infrastructure availability, enabling policy environments, and human capital development (World Bank, 2023). FinTech uptake has been most extensive, evidenced by millions of mobile money users and the integration of digital finance in agriculture, micro-insurance, and social welfare schemes. In contrast, AI uptake remains concentrated in research, startups, and pilot programs, with limited national-scale deployment due to infrastructure and skills deficits (Oxford Insights, 2024). Blockchain uptake is emerging through government-led digital identity and land registry projects, yet its scalability remains limited by regulatory uncertainty (UNCTAD, 2022). 5G uptake has begun in major cities, enabling telemedicine and industrial automation, but rural penetration remains low due to affordability barriers (GSMA, 2023). Clean energy uptake shows the strongest alignment with sustainability goals, as decentralized renewable systems have improved electricity access for millions, particularly through private-community partnerships (IRENA, 2022).

Notably, technological uptake in Africa often relies on hybrid models that blend traditional and modern systems. For example, digital financial platforms coexist with cash-based economies, while solar technologies complement existing grid systems. This hybridization demonstrates Africa's capacity for adaptive innovation, an evolution driven by necessity rather than imitation. The evolution, diffusion, acceptance, and uptake of emerging technologies in Africa represent an ongoing process of adaptation shaped by socio-technical systems and institutional dynamics. While FinTech and clean energy have achieved widespread diffusion, AI, blockchain, and 5G remain in developmental stages marked by infrastructural and regulatory challenges. The future trajectory of Africa's digital transformation depends on the interplay between innovation ecosystems, inclusive policies, and capacity-building initiatives that ensure technology serves as a driver of sustainable and equitable growth.

4. INTEGRATION OF EMERGING TECHNOLOGIES IN AFRICA

The integration of emerging technologies in Africa represents a critical phase in translating innovation into tangible socio-economic transformation. Unlike uptake, which refers to the initial adoption and use of technologies, integration involves embedding these innovations into economic systems, institutional frameworks, and social structures to create lasting value. Effective integration ensures that technological advancement moves beyond pilot projects or niche applications to deliver systemic benefits such as productivity growth, social inclusion, and environmental sustainability (World Bank, 2023; UNCTAD, 2022).



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Artificial Intelligence (AI) integration is gradually taking shape within key sectors, particularly health and agriculture. In healthcare, AI-driven diagnostic tools and data analytics systems are being integrated into public health programs to enhance disease surveillance and improve service delivery efficiency. In agriculture, AI-based advisory platforms are supporting farmers with weather predictions and crop management insights, linking innovation directly to productivity and food security outcomes (Niyirora, 2021). However, sustained integration depends on aligning digital innovation with national development priorities and strengthening institutional capacity for data governance and ethical oversight (Oxford Insights, 2024).

Financial Technology (FinTech) demonstrates a more advanced level of integration, particularly within social protection systems, microfinance institutions, and government payment infrastructures. In countries such as Kenya and Nigeria, mobile-based financial platforms are now embedded in public welfare disbursements, agricultural subsidies, and insurance schemes (GSMA, 2023). This integration not only enhances transparency and efficiency but also deepens financial inclusion across vulnerable populations. Nonetheless, scaling integration requires robust regulatory harmonization and cybersecurity frameworks to sustain public trust and system resilience (UNCTAD, 2022).

Blockchain technology is gradually being woven into institutional and governance structures across various African economies. Its integration in land registries, interbank settlements, and supply chain traceability systems illustrates how distributed ledger technologies can strengthen transparency and accountability (CBN, 2021; UNCTAD, 2022). However, realizing blockchain's full integrative potential requires interoperability with existing legacy systems, regulatory clarity, and technical competence among government and financial institutions. Without these, blockchain risks remaining a fragmented innovation rather than a transformative governance tool.

5G and data infrastructure integration marks a strategic enabler for digital transformation across multiple sectors. As African cities pursue smart city agendas, 5G networks are becoming integral to industrial automation, telemedicine, e-learning, and transportation systems (GSMA, 2023). Integrating these technologies creates interconnected urban ecosystems capable of improving service delivery and enhancing competitiveness. Yet, integration remains constrained by high deployment costs, spectrum allocation challenges, and uneven access between urban and rural regions. Coordinated investments in data centers, fiber-optic networks, and regulatory frameworks are crucial for sustaining integration momentum (World Bank, 2023).

Clean energy technologies represent one of the most successful cases of technological integration on the continent. Decentralized solar systems and mini-grids are increasingly embedded within local economies, powering schools, clinics, and small enterprises (IRENA, 2022). Their integration has demonstrated the potential to improve livelihoods, stimulate local economies, and advance environmental sustainability. Furthermore, the alignment of renewable energy projects with mobile payment systems has strengthened operational models, linking energy access to financial inclusion and community empowerment. However, scaling integration requires better maintenance systems, technical training, and long-term financing mechanisms to sustain progress.

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Overall, the integration of emerging technologies in Africa underscores the importance of aligning innovation with institutional structures, policy coherence, and social needs. Integration ensures that technologies transition from isolated applications to essential components of governance, economic productivity, and human development. Achieving this requires coordinated multi-stakeholder efforts, including public-private partnerships, capacity building, and inclusive regulatory reforms. By embedding technologies into the fabric of economic and social systems, Africa can harness their transformative potential to drive sustainable, inclusive growth and enhance resilience in the digital age.

5. THEORETICAL FRAMEWORKS APPLICABLE TO THE EVOLUTION, DIFFUSION, ACCEPTANCE, AND UPTAKE OF EMERGING TECHNOLOGIES IN AFRICA

The adoption and integration of emerging technologies in Africa can be better understood through established theoretical frameworks that explain innovation diffusion, user acceptance, and system-level uptake. These frameworks, rooted in innovation studies, information systems, sociology, and technology management, provide critical lenses for analyzing why certain technologies succeed while others face resistance. This section explores key theoretical approaches relevant to the trajectory of Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G Infrastructure, and Clean Energy technologies across Africa (Rogers, 2003; Davis, 1989; Venkatesh et al., 2003).

Several theoretical frameworks underpin analyses of technology diffusion and adoption in Africa. Rogers' (2003) Diffusion of Innovations theory explains adoption dynamics through attributes such as relative advantage and complexity. The Technology Acceptance Model (Davis, 1989) emphasizes perceived usefulness and ease of use, particularly relevant to FinTech and AI systems.

The Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003) extends this understanding by integrating social influence and facilitating conditions. Meanwhile, Innovation Systems Theory (Lundvall, 1992) and Socio-Technical Systems Theory (Trist & Emery, 1951) highlight the importance of institutional collaboration and contextual adaptation. Together, these frameworks provide a holistic understanding of Africa's technology ecosystem, linking human, technical, and institutional dimensions.

Diffusion of Innovations (DOI) Theory

Everett Rogers' Diffusion of Innovations Theory (1962, 2003) explains how new technologies spread within social systems. The theory identifies five stages of diffusion: knowledge, persuasion, decision, implementation, and confirmation, and categorizes adopters as innovators, early adopters, early majority, late majority, and laggards. In Africa, DOI theory helps explain patterns of technology adoption. For instance, M-Pesa's success in Kenya is attributed to the relative advantage of convenience and security, compatibility with existing financial practices, and observability among users (Jack & Suri, 2016). Conversely, the slow uptake of 5G networks illustrates challenges associated with complexity and limited trialability, demonstrating the need for supportive infrastructures and awareness programs (UNCTAD, 2022). DOI theory provides a foundational lens for analyzing both social and institutional factors influencing diffusion.

Technology Acceptance Model (TAM)

Davis' (1989) Technology Acceptance Model (TAM) posits that perceived usefulness and perceived ease of use determine users' behavioral intentions and eventual adoption of technology.

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In the African context, TAM is widely applied to FinTech, e-learning, and AI applications. For example, research indicates that perceived usefulness, particularly in reducing transaction time and cost, strongly predicts FinTech adoption in Nigeria and Ghana (GSMA, 2023; Oxford Insights, 2024). Similarly, AI applications, such as localized language processing tools, gain acceptance when users perceive them as relevant, accessible, and culturally aligned (Niyirora, 2021). TAM thus provides a user-centered understanding of technology adoption, highlighting the importance of usability and perceived value in diverse socio-economic settings.

Unified Theory of Acceptance and Use of Technology (UTAUT)

Venkatesh et al.'s (2003) UTAUT integrates constructs from multiple acceptance models, including performance expectancy, effort expectancy, social influence, and facilitating conditions. UTAUT is particularly relevant for explaining uptake of digital infrastructure and clean energy solutions, where collective and environmental factors influence adoption. In South Africa, for instance, social influence and enabling conditions such as energy subsidies and regulatory frameworks have promoted renewable energy adoption (IRENA, 2022). Similarly, performance expectancy drives 5G adoption in Kenya, where users anticipate improved communication and economic opportunities (GSMA, 2023). UTAUT emphasizes that technology adoption is a multi-dimensional process shaped by individual perceptions and contextual enablers.

Innovation Systems Theory

Innovation Systems Theory (Freeman, 1987; Lundvall, 1992) highlights the interactions among institutions, firms, and government agencies in fostering technological innovation. In Africa, the theory helps explain how AI innovation hubs, FinTech startups, and public agencies co-evolve to support technology ecosystems (Oxford Insights, 2024; World Bank, 2023). For example, partnerships between universities, private firms, and government initiatives have catalyzed AI research in Kenya and Ghana, while FinTech growth in Nigeria is supported by regulatory sandboxes and venture capital. Innovation Systems Theory underscores the importance of coordinated networks in sustaining technology evolution, diffusion, and uptake.

Socio-Technical Systems (STS) Theory

STS Theory (Trist & Emery, 1951) views technology adoption as the outcome of interactions between technical and social subsystems. Successful technological uptake requires alignment between technical design and social, cultural, and organizational contexts. In Africa, STS theory explains differential success of technologies across regions. Pay-as-you-go solar systems thrive in East Africa due to community financing structures and local service networks, whereas similar systems struggle elsewhere because of weak social integration (IRENA, 2022). STS highlights the necessity of considering human behavior, institutional support, and cultural norms in technology implementation.

Actor–Network Theory (ANT)

Actor–Network Theory (Latour & Callon) conceptualizes technology adoption as the product of networks of human and non-human actors, including developers, policymakers, institutions, and machines. In Africa, ANT illuminates the dynamics behind projects like Nigeria's eNaira, where central banks, software developers, and citizens collectively shape the technology's meaning and use (CBN, 2021). ANT emphasizes power relations, negotiations, and inter-dependencies, providing a nuanced understanding of uptake and integration processes.



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The adoption and integration of emerging technologies in Africa are influenced by multiple theoretical perspectives. DOI explains the diffusion patterns, TAM and UTAUT offer insights into user acceptance, Innovation Systems Theory highlights institutional interactions, STS emphasizes social-technical alignment, and ANT illustrates networked actor influences. Together, these frameworks provide a comprehensive lens to analyze the evolution, diffusion, acceptance, and uptake of technologies such as AI, FinTech, Blockchain, 5G, and Clean Energy across diverse African contexts.

6. FINDINGS ON USEFULNESS AND TECHNOLOGY GAPS/LIMITATIONS OF EMERGING TECHNOLOGIES IN AFRICA

Emerging technologies in Africa including Financial Technology (FinTech), Artificial Intelligence (AI), Blockchain, 5G Infrastructure, and Clean Energy/Climate Technologies have shown significant potential to drive socio-economic development. Their usefulness is evident in several areas. However, their diffusion, adoption, and integration remain uneven across the continent due to a combination of structural, institutional, and human capacity limitations (World Bank, 2023; UNCTAD, 2022). This section critically examines both the benefits and the challenges associated with these technologies.

Financial Technology (FinTech / Embedded Finance)

FinTech has emerged as one of the most impactful innovations in Africa, particularly through mobile money platforms such as M-Pesa in Kenya and Paystack in Nigeria. These platforms have transformed financial landscapes by providing secure, low-cost transactions, facilitating microfinance, and supporting small and medium enterprises (SMEs), thereby contributing to poverty reduction and economic resilience (Jack & Suri, 2016; GSMA, 2023). Nevertheless, challenges persist. Cross-border regulatory fragmentation restricts interoperability, limiting the potential for seamless financial transactions across countries. Cybersecurity vulnerabilities also undermine user confidence, while rural populations remain underserved due to infrastructure and affordability constraints. Moreover, overreliance on venture capital exposes startups to financial instability, which can disrupt continuity and expansion (World Bank, 2023). Consequently, while FinTech demonstrates clear utility, its sustainable uptake requires targeted policy, regulatory harmonization, and infrastructure investment.

Artificial Intelligence (AI & Machine Learning)

AI applications in Africa have begun to support health diagnostics, precision agriculture, and language processing, offering localized and contextually relevant solutions. For instance, AI-powered agricultural advisory services enhance farmers' decision-making, while initiatives like Masakhane support Natural Language Processing (NLP) for African languages, improving accessibility and localization (Niyirora, 2021). Despite these benefits, adoption is constrained by limited representative datasets, high computational costs, intermittent connectivity, and a shortage of local technical expertise.

Ethical and governance challenges, including concerns over bias, privacy, and algorithmic accountability, further complicate widespread implementation (Oxford Insights, 2024; World Bank, 2023). Thus, although AI shows transformative potential, its integration requires capacity building, governance frameworks, and infrastructure improvements to achieve sustainable and inclusive adoption.



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Blockchain, Crypto, and Web3

Blockchain technologies offer transparent, secure, and immutable solutions for governance, financial inclusion, and supply chain management. Projects such as Nigeria's eNaira and Ghana's Bitland exemplify practical applications, illustrating the potential for blockchain to enhance efficiency, reduce fraud, and improve trust in public systems (CBN, 2021; UNCTAD, 2022). However, the uptake of blockchain is uneven. Regulatory uncertainty, energy-intensive processes, and low digital literacy hinder adoption. Additionally, speculative interest in cryptocurrencies often overshadows their practical applications, limiting systemic integration (Chainalysis, 2024; UNCTAD, 2022). Therefore, while blockchain demonstrates significant utility, its impact depends on regulatory clarity, capacity building, and public awareness campaigns to enable meaningful integration into African socio-economic systems.

5G and Data Infrastructure

The deployment of 5G networks and enhanced data infrastructure has improved connectivity, enabling low-latency applications such as telemedicine, smart agriculture, e-learning, and industrial automation (GSMA, 2023). Urban centers in Africa have benefitted most, demonstrating how connectivity can drive innovation, productivity, and service delivery. Yet, adoption remains constrained by high infrastructure costs, limited device affordability, and unreliable energy supply. Rural communities, in particular, are underserved, which exacerbates the digital divide (UNCTAD, 2022). These challenges suggest that while 5G holds transformative potential, equitable integration requires targeted investment, policy support, and innovative financing models.

Clean Energy and Climate Technologies

Renewable energy technologies, such as solar mini-grids and pay-as-you-go home systems, have significantly improved energy access in off-grid communities, enabling productive uses and reducing reliance on fossil fuels (IRENA, 2022). National initiatives, including South Africa's REIPPP, illustrate the potential to attract private investment and expand renewable energy generation. Nonetheless, there are challenges. Technical capacity and maintenance in rural areas are limited, upfront costs remain high, and supply chain gaps hinder scalability. Transitioning from pilot projects to full-scale national integration remains slow, indicating the need for institutional support, long-term financing, and community engagement (World Bank, 2023).

AI, FinTech, and blockchain rely on robust data infrastructure and energy availability. Many interventions remain at pilot stages; achieving sustainability requires institutional support, long-term financing, and human capital development. Without deliberate strategies, benefits tend to concentrate in urban areas, leaving rural and marginalized populations at risk of exclusion. Effective adoption requires harmonized regulations, interoperability standards, and capacity-building initiatives (World Bank, 2023; UNCTAD, 2022). These observations highlight that while emerging technologies offer transformative potential, their benefits are contingent on supportive infrastructure, policy, and socio-economic integration.



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7. RECOMMENDATIONS FOR POLICY, RESEARCH, AND PRACTICE IN EMERGING TECHNOLOGIES IN AFRICA

Emerging technologies including Financial Technology (FinTech), Artificial Intelligence (AI), Blockchain, 5G Infrastructure, and Clean Energy offer considerable potential for socio-economic development in Africa. However, their adoption and sustainable integration are constrained by several issues. It is essential to adopt a multi-dimensional approach to policy, research, and practice that not only promotes uptake but also ensures equitable, sustainable, and contextually appropriate implementation.

7.1 Policy Recommendations

Policy frameworks play a central role in enabling technology adoption. Harmonizing cross-border regulations is critical for digital finance and mobile money interoperability, as fragmented policies can impede cross-country financial transactions (GSMA, 2023). Strengthening consumer protection and cybersecurity regulations is equally vital to build trust and safeguard users from fraud and data breaches (World Bank, 2023).

Inclusive financial strategies targeting women, rural populations, and marginalized communities are necessary to prevent technology from exacerbating existing inequalities. Similarly, AI adoption requires well-structured national strategies that integrate ethical guidelines, data privacy safeguards, and algorithmic accountability (Oxford Insights, 2024). Open data and local data governance initiatives can further enhance AI and analytics by improving access to high-quality, representative datasets.

Blockchain and digital currency adoption also depend on clear legal frameworks, complemented by regulatory sandboxes that allow controlled experimentation (UNCTAD, 2022). For connectivity and broadband expansion, inclusive policies and spectrum reforms, combined with infrastructure-sharing incentives, can address urban-rural disparities (GSMA, 2023). As for renewable energy, policies must promote public-private partnerships, blended financing models, and local standards to ensure that deployment is sustainable and scalable (IRENA, 2022).

Above all, policies should not only enable adoption but also anticipate and mitigate risks while promoting equity, inclusivity, and sustainability.

7.2 Research Recommendations

Research is crucial for evidence-based decision-making and adaptive technology strategies. Longitudinal studies on FinTech adoption can reveal the socio-economic impacts of digital finance interventions, while research into digital literacy programs can identify barriers and enablers for different demographic groups. Interdisciplinary investigations into AI applications spanning agriculture, healthcare, education, and governance can ensure technologies are adapted to African contexts. Concurrently, research should focus on bias, fairness, and inclusivity in AI models to avoid reinforcing social inequalities (Oxford Insights, 2024). Blockchain initiatives require careful evaluation to understand scalability, sustainability, and governance outcomes, while the environmental and energy implications of both blockchain and 5G technologies demand rigorous assessment (IRENA, 2022; UNCTAD, 2022). Investigating the digital divide, affordability, and the socio-economic impacts of decentralized renewable energy systems can also guide more effective interventions. Collectively, research should generate actionable insights that support equitable and sustainable technology deployment.



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7.3 Practice Recommendations

Practical implementation strategies are necessary to translate policy and research into real-world impact. Expanding rural networks and mobile access points is essential for bridging service gaps, while integrating FinTech solutions with other development services such as agriculture, healthcare, and social welfare, enhances relevance and adoption. Building technical and managerial capacity in AI, blockchain, 5G, and renewable energy through training, collaborations, and partnerships ensures that local stakeholders can operate and sustain technologies. Localization of systems including language, cultural context, and affordability further enhances adoption and utility.

Additionally, training for developers, regulators, and end-users strengthens understanding of complex technologies. Focusing on high-impact use cases, such as financial inclusion, transparent supply chains, and secure digital identity systems, ensures that resources are prioritized effectively before scaling interventions. Long-term sustainability requires local capacity for installation, maintenance, and spare parts management, particularly for energy and connectivity infrastructures. Inclusive financing models, including pay-as-you-go and blended financing approaches, can facilitate access for marginalized populations.

8. CONCLUSION

This study underscores that Africa's technological transformation stands at a decisive crossroads. The examination of five emerging technologies Financial Technology (FinTech), Artificial Intelligence (AI), Blockchain, 5G and Data Infrastructure, and Clean Energy or Climate Technologies reveals their immense potential to reshape Africa's socio-economic, institutional, and infrastructural systems. However, sustainable and inclusive digital transformation in Africa requires deliberate coordination between policy, capacity, and context. Building adaptive governance systems, strengthening institutional and technical capacities, and fostering inclusive digital ecosystems are indispensable for ensuring that emerging technologies contribute to equitable growth rather than exacerbate existing inequalities. When guided by coherent policies, localized innovation, and regional cooperation, Africa can harness emerging technologies not merely as tools for modernization but as catalysts for resilience, competitiveness, and inclusive development.

9. FUTURE DIRECTIONS OF EMERGING TECHNOLOGIES IN AFRICA

The trajectory of emerging technologies in Africa, including: Artificial Intelligence (AI), Financial Technology (FinTech), Blockchain, 5G Infrastructure, and Clean Energy/Climate Technologies, reflects a dynamic interplay between technological innovation, socio-economic needs, and policy environments. While the continent has made significant strides in adoption, there remains substantial potential for deeper integration and sustainable impact. In the FinTech sector, the focus is shifting toward cross-border integration and digital ecosystems. Mobile money platforms and embedded finance solutions are increasingly expected to reach underserved populations, particularly in rural areas. Harmonized regulatory frameworks across African countries, supported by initiatives like the African Continental Free Trade Area (AfCFTA), can enhance interoperability and scale (GSMA, 2023). Additionally, integrating FinTech with services in agriculture, healthcare, and education presents an opportunity to generate multidimensional socio-economic benefits, building on the successes of platforms like M-Pesa and Paystack (Jack & Suri, 2016).



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AI development in Africa is poised to advance through localization, capacity building, and collaborative research. African-specific AI applications, such as NLP for local languages and decision-support tools for agriculture and health, are likely to gain traction as data infrastructure improves (Niyirora, 2021). Furthermore, public-private-academic partnerships can address skills gaps, while the development of ethical and regulatory frameworks will be crucial to ensure responsible, inclusive deployment (Oxford Insights, 2024).

Blockchain and Web3 technologies are expected to expand beyond cryptocurrencies into governance, supply chains, and decentralized finance (DeFi). Future adoption will depend on establishing clear regulatory environments, fostering energy-efficient solutions, and building local capacity for development and user engagement (CBN, 2021; UNCTAD, 2022). Integration with government services offers the potential to enhance transparency and efficiency, which is essential for sustainable uptake. The expansion of 5G networks and data infrastructure will underpin smart cities, industrial automation, and digital public services. However, adoption must prioritize rural connectivity, affordable devices, and localized content to prevent exacerbating the digital divide (GSMA, 2023).

Policy reforms, including spectrum allocation and interoperability standards, will be critical for ensuring that these networks serve as platforms for innovation rather than creating isolated pockets of access (World Bank, 2023). Clean energy and climate technologies are projected to continue growing through decentralized renewable solutions, such as solar mini-grids and pay-as-you-go home systems. Strengthening local maintenance capacity, leveraging public-private partnerships, and developing sustainable financing models will be vital to ensure long-term adoption (IRENA, 2022). Aligning renewable energy deployment with productive uses in agriculture and small-scale industry can amplify developmental impact.

Across all sectors, several cross-cutting considerations emerge. Localization and cultural adaptation remain essential to technology uptake, ensuring that solutions are contextually relevant and accessible. Capacity building for both technical and managerial, is critical for sustaining innovation ecosystems. Inclusive policies and governance frameworks, supported by interoperability standards and long-term maintenance planning, will determine whether emerging technologies achieve their full developmental potential. In addition, financing models that blend public investment, private capital, and pay-as-you-go systems are likely to enhance scalability and sustainability.

The future of emerging technologies in Africa will be shaped not only by the technologies themselves but by the extent to which they are adapted to local contexts, integrated with socio-economic systems, and supported by inclusive policies, strong governance, and capacity-building initiatives. Strategic coordination among governments, private sector actors, research institutions, and communities will be essential to translate technological innovation into meaningful socio-economic outcomes across the continent (UNCTAD, 2022; World Bank, 2023).

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