(REVIEW ARTICLE)

Conceptualizing emerging technologies and ICT adoption: Trends and challenges in Africa-US contexts

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Abstract

This review paper explores the adoption trends, challenges, and opportunities surrounding Information and Communication Technology (ICT) and emerging technologies in the Africa-US contexts. It identifies key drivers influencing technology adoption and outlines innovative solutions for sustainable development by analyzing the current state of ICT infrastructure, policy frameworks, socio-economic factors, and cultural considerations. The comparative analysis highlights disparities between Africa and the US while emphasizing the potential for cross-continental collaborations. Implications for stakeholders, including governments, businesses, NGOs, and communities, and recommendations for fostering an enabling environment for technology adoption are discussed. By addressing gaps in research and embracing collaborative efforts, ICT and emerging technologies can drive transformative change, promoting inclusive growth and societal advancement in both regions.

Keywords: ICT Adoption; Emerging Technologies; Africa-US Relations; Sustainable Development; Cross-Continental Collaborations; Policy Recommendations.

1. Introduction

Information and Communication Technology (ICT) and emerging technologies have ushered in a new era of global interconnectedness, reshaping economies, societies, and how we interact with the world around us (Edoho, 2013; Park & Roome, 2017). This review paper delves into the profound impact of these technologies, with a keen focus on their adoption trends and the attendant challenges within the Africa-US contexts. The discussion spans a broad spectrum of innovations, from foundational ICT infrastructure, such as mobile telecommunications and internet access, to cutting-edge advancements like artificial intelligence (AI), blockchain, the Internet of Things (IoT), and big data analytics. These technologies, characterized by their rapid evolution and potential for wide-ranging applications, offer unprecedented opportunities for economic growth, social development, and the enhancement of public services.

ICT encompasses diverse technologies designed to store, retrieve, manipulate, transmit, or receive information electronically in a digital form (Aceto, Persico, & Pescapé, 2018; Jamila, 2012). This includes traditional components like radio, television, and mobile phones, extending to more advanced systems such as cloud computing, digital platforms, and cybersecurity technologies. Emerging technologies refer to those innovations that represent progressive developments within a field for competitive advantage. In the context of this review, the focus is on technologies that hold significant transformative potential for both Africa and the US, such as AI, which is revolutionizing sectors from healthcare to agriculture through predictive analytics and automation; blockchain, offering secure and transparent

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transaction mechanisms; IoT, enabling interconnected digital networks of physical devices; and big data analytics, providing insights from vast and complex datasets.

The Africa-US axis serves as a pivotal lens through which to examine the dynamic interplay of technology adoption across diverse economic and socio-political landscapes. With its vast resources and burgeoning youth population, Africa presents a fertile ground for technological innovation and digital entrepreneurship. The US, a global technology leader, offers a blueprint for the integration of advanced technologies into economic, social, and governance frameworks. This bilateral perspective highlights the contrasts in technology adoption rates, infrastructure readiness, and innovation ecosystems and underscores the mutual benefits of collaboration, knowledge exchange, and investment in bridging the digital divide. Understanding the nuances of technology adoption in these regions is crucial for harnessing ICT for sustainable development, fostering inclusive growth, and mitigating the risks associated with digital transformation.

The primary objective of this paper is to articulate a comprehensive overview of the current landscape of ICT and emerging technology adoption within Africa and the US, identifying key trends, challenges, and opportunities. It aims to dissect the factors driving technology uptake, the barriers impeding access and utilization, and the socio-economic implications of these technologies on both continents. By doing so, the review seeks to offer insights into effective strategies for leveraging ICT and emerging technologies to address critical development challenges, promote innovation, and enhance competitiveness in the global economy. The rationale for this review stems from the critical role of ICT and emerging technologies in shaping the future of economies and societies worldwide. As digital transformation accelerates, understanding the factors influencing technology adoption and the resultant impacts is paramount for policymakers, businesses, and civil society. This review contributes to academic research by synthesizing current knowledge on technology trends and adoption challenges, providing a comparative analysis of the Africa-US contexts. It informs policy-making by highlighting best practices and lessons learned, thereby guiding strategic decisions in technology investment, regulation, and capacity building. For practitioners, it offers a framework for navigating the complexities of digital innovation and leveraging technology for sustainable development. Ultimately, this review underscores the significance of fostering an inclusive digital world where the benefits of ICT and emerging technologies are equitably shared across and within societies.

2. Trends in ICT and Emerging Technology Adoption in Africa and the US

2.1. Current State of ICT in Africa

Africa has experienced remarkable ICT infrastructure and adoption growth over the past few decades, albeit with significant disparities across regions and countries (Billon, Marco, & Lera-Lopez, 2009; Pigato, 2001). Penetration rates for mobile telephony have soared, surpassing traditional landline networks, and mobile internet usage has proliferated, driven by the widespread availability of affordable smartphones. However, challenges such as inadequate infrastructure, limited access to electricity, and a lack of digital literacy persist, particularly in rural and underserved areas (A. S. George, George, & Baskar, 2023; Steinbock, 2005).

ICT has facilitated telemedicine initiatives, remote patient monitoring, and electronic health record systems in the healthcare sector, improving access to healthcare services and enhancing patient outcomes (Awwad, 2021). Mobile health (mHealth) applications have enabled delivering essential health information, disease surveillance, and medication adherence support, particularly in remote and resource-constrained settings (Abaza & Marschollek, 2017; Osei & Mashamba-Thompson, 2021). ICT is revolutionizing education delivery in Africa, with initiatives such as e-learning platforms, virtual classrooms, and digital content repositories expanding access to quality education. Mobile-based learning solutions, interactive multimedia tools, and online courses offer flexibility and personalized learning experiences, bridging educational gaps and empowering learners of all ages. The advent of mobile money services, pioneered by platforms like M-Pesa in Kenya, has revolutionized financial inclusion in Africa (Burns, 2018; Donovan, 2012). Mobile payment solutions have transformed banking practices, enabling peer-to-peer transfers, bill payments, and access to credit and savings products for millions of unbanked individuals. Fintech innovations continue to drive financial sector transformation, with mobile banking, digital lending, and blockchain-based solutions gaining traction (Lashitew, van Tulder, & Liasse, 2019).

2.2. Emerging Technologies in the US

In the United States, a hub of technological innovation, emerging technologies rapidly advance across various sectors, fueling economic growth and societal transformation.

AI technologies, encompassing machine learning, natural language processing, and computer vision, are being deployed across diverse industries in the US. In healthcare, AI-driven diagnostics, predictive analytics, and personalized treatment recommendations are improving patient outcomes and operational efficiency. AI algorithms power automated trading systems, fraud detection mechanisms, and personalized financial advice platforms in finance, enhancing decision-making and risk management. Blockchain technology, known for its decentralized and immutable ledger system, is disrupting traditional business models and processes. In the US, blockchain applications span financial services, supply chain management, healthcare, and digital identity verification. Cryptocurrencies, built on blockchain platforms, have gained traction as alternative forms of payment and investment, with growing acceptance from mainstream institutions (Gurguc & Knottenbelt, 2018; Varma, 2019).

The IoT ecosystem in the US is expanding rapidly, connecting billions of devices and sensors to the internet to collect, transmit, and analyze data in real-time (Sharma, Shamkuwar, & Singh, 2019). Smart home devices, wearable technology, and industrial IoT solutions transform daily life and business operations. IoT-enabled predictive maintenance, asset tracking, and inventory management systems optimize production processes and reduce downtime in manufacturing (Georgakopoulos & Jayaraman, 2016; Munirathinam, 2020).

3. Comparative Analysis

3.1. Despite significant strides in ICT and emerging technology adoption, disparities between Africa and the US remain pronounced.

While Africa has seen rapid growth in mobile telephony and internet penetration, adoption rates for advanced technologies like AI and IoT lag behind those in the US. Access to high-speed internet, digital infrastructure, and skilled workforce remain major barriers to technology uptake in Africa. Both Africa and the US are witnessing technology-driven transformations across healthcare, education, finance, agriculture, and other sectors. However, the scale and scope of implementation vary, with the US leading in deploying cutting-edge solutions and innovative applications (Ndulu, 2007).

In the US, robust technological infrastructure, favorable regulatory environment, and robust investment ecosystem foster a culture of innovation and entrepreneurship, enabling widespread adoption of emerging technologies. In contrast, Africa faces infrastructural challenges, regulatory barriers, and limited investment in research and development, hindering the scale of technology implementation (Datta, Byrd, Okoli, & Mbarika, 2005; G. George, Corbishley, Khayesi, Haas, & Tihanyi, 2016).

3.2. Drivers of Adoption

In the US, supportive government policies, including research grants, tax incentives, and regulatory frameworks, incentivize innovation and technology adoption. In Africa, governments increasingly recognize the strategic importance of ICT and implement policies to promote digital inclusion, attract investment, and foster innovation ecosystems. In both regions, private sector investment plays a crucial role in driving technology adoption. Venture capital funding, corporate partnerships, and startup incubators fuel the growth of tech startups and facilitate the commercialization of innovative solutions (Cornelius, 2020; Srinivasan, Barchas, Gorenberg, & Simoudis, 2014). Addressing societal challenges, such as healthcare access, education quality, and financial inclusion, is a key driver for technology adoption in Africa and the US. Technologies that offer tangible benefits and address pressing needs are more likely to gain traction and achieve widespread adoption.

In conclusion, while Africa and the US are at different stages of technological development, both regions are experiencing profound shifts in ICT and emerging technology adoption. Understanding the trends, challenges, and drivers of adoption is essential for fostering inclusive growth, addressing development gaps, and leveraging technology for sustainable development in Africa-US contexts.

4. Challenges in Adopting Emerging Technologies in Africa-US Contexts

4.1. Infrastructure and Accessibility

One of the primary challenges in Africa is the inadequate ICT infrastructure, including limited internet access, unreliable electricity supply, and poor technological literacy (Pigato, 2001). Rural areas often lack basic connectivity, hindering the adoption of emerging technologies. Additionally, frequent power outages and high data costs further exacerbate the accessibility issues, restricting the use of digital services and applications (Simmhan, Kumbhare, Cao, & Prasanna, 2011).

While the US boasts relatively advanced ICT infrastructure compared to Africa, disparities in internet access persist, particularly in rural and low-income communities. The digital divide, compounded by factors such as affordability and digital literacy, hampers equitable access to emerging technologies. Furthermore, energy consumption by data centers and IoT devices poses environmental concerns and strains existing infrastructure.

4.2. Policy and Regulatory Environment

In many African countries, regulatory frameworks for technology adoption and innovation are fragmented and often outdated, hindering investment and stifling innovation. Complex licensing procedures, restrictive data localization requirements, and limited intellectual property protection discourage both domestic and foreign investment in emerging technologies. Additionally, inconsistent enforcement of regulations and corruption pose further challenges to a conducive business environment. The regulatory landscape in the US is relatively more established, with clear guidelines governing technology adoption and innovation. However, issues like net neutrality, data privacy regulations, and antitrust concerns present ongoing challenges. The pace of technological innovation often outstrips the capacity of regulators to keep up, leading to regulatory gaps and uncertainties that may inhibit innovation or pose risks to consumer protection and privacy.

4.3. Socio-Economic Factors

Socio-economic disparities, including education, income levels, and urban-rural divides, significantly impact technology adoption in Africa (Anlimachie & Avoada, 2020). Limited access to quality education and digital skills training exacerbates the digital divide, restricting opportunities for individuals to participate in the digital economy. Moreover, income inequality and poverty rates influence purchasing power and affordability of technology devices and services, further widening the gap between tech-savvy urban elites and marginalized communities (Chutani, Aalami, & Badshah, 2010). Socio-economic factors also play a crucial role in technology adoption within the US. Disparities in access to education and digital skills training contribute to the digital divide, with marginalized communities facing barriers to entry into the technology sector. Income inequality and poverty rates affect affordability and access to technology devices and high-speed internet, perpetuating disparities in digital access and opportunities for socio-economic advancement (Addy et al., 2024a, 2024b; Akindote et al., 2023; Akindote, Adegbite, Omotosho, Anyanwu, & Maduka, 2024; Garrity, 2015; Hilbert, 2010; Oguejiofor et al., 2023).

4.4. Cultural and Ethical Considerations

Cultural factors and societal norms can influence adopting and using emerging technologies in Africa. Privacy concerns, particularly in collectivist societies, may deter individuals from embracing digital technologies that require sharing personal information. Moreover, traditional beliefs and practices may conflict with modern technological advancements, leading to resistance or reluctance to adopt new technologies. Additionally, ethical considerations surrounding data protection, cybersecurity, and digital rights are increasingly important in shaping technology adoption policies and practices. Cultural and ethical considerations in the US also shape technology adoption and use. Privacy concerns, fueled by high-profile data breaches and surveillance scandals, have led to calls for stricter regulations and greater transparency in data handling practices. Social norms regarding technology use, such as expectations of constant connectivity and digital engagement, may contribute to issues such as technology addiction and digital fatigue. Moreover, ethical dilemmas surrounding AI ethics, algorithmic bias, and responsible AI deployment require careful consideration and regulation to ensure equitable and ethical use of emerging technologies (Gupta, Bodhi, & Salim, 2024; Marsh, Vallejos, & Spence, 2022).

In conclusion, the challenges in adopting emerging technologies in Africa-US contexts are multifaceted, encompassing infrastructural, policy, socio-economic, cultural, and ethical dimensions. Addressing these challenges requires concerted efforts from governments, private sector stakeholders, civil society, and international organizations to create an enabling environment for technology innovation, promote digital inclusion, and harness the transformative potential of emerging technologies for sustainable development and societal advancement.

5. Opportunities for Leveraging ICT for Sustainable Development

5.1. Innovative Solutions for Development Challenges

ICT and emerging technologies offer innovative solutions to address key development challenges in Africa. For example, mobile health (mHealth) applications enable remote diagnosis and treatment, overcoming barriers to healthcare access in rural areas (Weinstein et al., 2014). In agriculture, precision farming techniques powered by IoT sensors and data analytics optimize crop yields and resource use, enhancing food security and livelihoods. Furthermore, blockchain

technology facilitates transparent and secure transactions in finance and supply chain management sectors, reducing inefficiencies and corruption. Similarly, in the US, ICT and emerging technologies are being leveraged to tackle development challenges and promote sustainable development (Peprah et al., 2020). AI-driven healthcare solutions improve diagnostic accuracy, treatment outcomes, and patient care delivery. Smart city initiatives utilize IoT sensors and big data analytics to enhance urban planning, transportation systems, and environmental sustainability. Furthermore, blockchain-enabled platforms facilitate peer-to-peer transactions, decentralized finance, and transparent supply chains, fostering economic inclusion and social equity (Adekanmbi et al., 2024; Aysan, Bergigui, & Disli, 2021; Dada et al., 2024).

5.2. Cross-Continental Collaborations

Collaborations between Africa and the US in technology development, research, and innovation hold immense potential for mutual benefit and sustainable development.

Research Partnerships: Joint research initiatives and academic collaborations between universities and research institutions in Africa and the US can foster knowledge exchange, technology transfer, and capacity building. Collaborative research projects in AI, renewable energy, and healthcare innovation can address shared development challenges and drive innovation.

Industry Partnerships: Public-private partnerships between African and US-based companies can accelerate technology adoption and promote entrepreneurship. Collaborations in fintech, e-commerce, and digital infrastructure development can spur economic growth, job creation, and innovation ecosystems.

Knowledge Sharing: Knowledge-sharing platforms, such as conferences, workshops, and online forums, facilitate dialogue and collaboration between African and US stakeholders. Exchange programs, mentorship initiatives, and technology transfer agreements enable the transfer of expertise, best practices, and innovative solutions across borders (Zelenika & Pearce, 2014).

5.3. Policy Recommendations

To support the adoption of ICT and emerging technologies in a way that promotes sustainable development, policymakers in Africa and the US should consider the following recommendations:

- Prioritize investment in ICT infrastructure, including broadband connectivity, digital literacy programs, and renewable energy solutions, to bridge the digital divide and ensure equitable access to technology.
- Invest in education and skills development programs to enhance digital literacy, technical expertise, and entrepreneurship capabilities, particularly among marginalized communities and underserved regions.
- Establish clear and transparent regulatory frameworks that promote innovation, protect consumers, and incentivize investment in emerging technologies. Ensure regulatory flexibility to accommodate technological advancements while safeguarding privacy, data protection, and cybersecurity.
- Foster innovation ecosystems through public-private partnerships, incubators, and startup accelerators to support technology entrepreneurship, research commercialization, and technology transfer.
- Develop inclusive digital policies that prioritize the needs of marginalized populations, including women, youth, persons with disabilities, and rural communities. Ensure that digital solutions are accessible, affordable, and culturally appropriate.

6. Conclusion and Future Directions

Throughout this review, we have examined the intricate landscape of ICT and emerging technology adoption in the Africa-US contexts. We have identified significant trends, challenges, and opportunities shaping the digital transformation journey in both regions.

In Africa, rapid advancements in mobile technology have driven substantial improvements in access to communication and basic services. However, challenges such as inadequate infrastructure, policy gaps, socio-economic disparities, and cultural barriers hinder emerging technologies' widespread adoption and effective utilization. In contrast, the US boasts a mature technological ecosystem characterized by robust infrastructure, innovative policies, and a thriving entrepreneurial culture. Nonetheless, persistent issues such as the digital divide, regulatory complexities, and ethical dilemmas underscore the need for continuous adaptation and innovation.

The findings of this review carry profound implications for various stakeholders in Africa and the US. Governments play a critical role in creating an enabling environment for technology adoption by investing in infrastructure, promoting digital literacy, and implementing supportive policies. Businesses have the opportunity to drive innovation and economic growth through strategic investments in emerging technologies and cross-continental collaborations. NGOs and civil society organizations can leverage ICT to address development challenges, promote social inclusion, and empower marginalized communities. Communities themselves stand to benefit from improved access to essential services, enhanced livelihood opportunities, and greater connectivity.

While this review comprehensively analyses current trends and challenges, several areas warrant further research attention. Firstly, there is a need for more empirical studies examining the socio-economic impacts of ICT and emerging technologies in Africa and the US, particularly in sectors such as healthcare, education, and finance. Additionally, research exploring the role of cultural and ethical considerations in technology adoption and usage patterns would enrich our understanding of cross-cultural dynamics. Furthermore, investigations into innovative business models, policy interventions, and technological solutions tailored to the unique needs of African contexts are essential for driving sustainable development.

ICT and emerging technologies hold immense potential to transform societies and economies in Africa and the US. By embracing collaborative efforts and innovative approaches, we can harness these technologies to address complex challenges, spur economic growth, and foster inclusive development. Cross-continental collaborations between Africa and the US offer opportunities for knowledge exchange, technology transfer, and capacity building, paving the way for shared prosperity and sustainable progress. With a shared vision of harnessing technology for the greater good, we can build a future where digital innovation serves as a catalyst for positive change, leaving no one behind in the journey towards prosperity and well-being.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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