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Africa and the Fourth Industrial Revolution: A Historical Analysis

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Abstract

This study examines Africa's engagement with the Fourth Industrial Revolution (4IR) from a historical and structural perspective, situating contemporary technological change within the longue durée of global industrial development and Africa's constrained position within the longue durée of global industrial development. It interrogates the dual character of the 4IR as both an opportunity for leapfrogging into knowledge-based development and a mechanism that may reproduce techno-colonial relations through data extraction, digital dependency, and unequal global value chains (GVCs). The analysis shows that colonial legacies and post-independence policy limitations have restricted Africa's industrial and technological sovereignty, shaping its enduring digital and economic vulnerabilities. The results indicate that Africa's participation in the 4IR remains uneven owing to infrastructural deficits, limited research and development capacity, and low digital inclusion, despite sectoral advances in mobile money, fintech, and agricultural innovation. Regional initiatives such as the African Continental Free Trade Area (AfCFTA) and Smart Africa are identified as key drivers of harmonizing digital policies, expanding intra-African trade, and strengthening collective bargaining in global digital governance. Using a qualitative historical-comparative method based on secondary sources, this study critically reinterprets existing literature on Africa's technological evolution from pre-colonial systems to modern digital economies. The study concludes that achieving digital sovereignty, strengthening human capital, and embedding African epistemologies and sustainability principles are essential for equitable 4IR integration.

Keywords: Fourth Industrial Revolution, Africa, Industrialization, Sustainability

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Introduction

The word "revolution" denotes an abrupt and radical change. Revolutions have occurred throughout history when new technologies and novel ways of perceiving the world have triggered profound changes in economic systems and social structures. (Klaus Schwab, 2016) With a deeper understanding of some of the key principles of Industry 4.0, one could be prepared to explore how intelligent production will revolutionize the way of doing business. In the 1990s, connectivity and exchange of information were revolutionized by the boom in the Internet and telecommunications industry. This has contributed to structural shifts in production and conventional industrial processes, combining physical and technological borders. This boundary is further blurred by cyber-physical systems (CPSs), which contribute to various rapid technical disorders in the industry. CPSs allow machines to communicate with each other with almost no physical or geographical barriers. (Sangaiah, & Siarry, 2022).

There is an urgent need for Africans to transform their continent through scientific and technological knowledge to satisfy their needs and invariably becomes more competitive. This represents a shift from traditional knowledge to scientific and technological knowledge. This shift would require changing Africa's economic structure from the predominantly agricultural to the industrial; it would entail adding value to the vast reservoir of Africa's abundant raw materials by processing them locally. (Cooper, 2005). In other words, it is a call for unfettered industrialization, as the West experienced years ago. Unlike the liberal and laissez-faire projections of some Western scholars, industrialized countries have been supportive of their homegrown manufacturing and industrial sectors. Analysts such as Lin and Monga (2010) adduced some historical illustrations that attest to the fact that industrialized countries had used a combination of trade, industrial, and

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technological policies to favor their homegrown companies. The United Nations General Assembly's declaration of 20 November as Africa Industrialization Day is situated within this broader historical and developmental framework.

> *In July 1989, the Organization of African Unity (O.A.U.) conducted its 25th Ordinary Session of the Assembly of Heads of State and Government in Addis Ababa, Ethiopia. Africa Industrialization Day was announced on November 20 during this session. Within the framework of the Second Industrial Development Decade for Africa (1991-2000), the United Nations General Assembly, in December 1989, proclaimed 20 November "Africa Industrialization Day" (A/RES/44/237). Since then, the United Nations System has held events on that day throughout the world to raise awareness about the importance of Africa's industrialization and the challenges faced by the continent*. (United Nations, 1989)

Revolution 1. 0: The First Industrial Revolution

The Industrial Revolution, sometimes called the First Industrial Revolution, was a transitional period of the global economy toward more widespread, efficient, and stable manufacturing processes, succeeding the Second Agricultural Revolution. Beginning in Great Britain around 1760, the Industrial Revolution had spread to continental Europe and the United States by about 1840 (Harris, 1988). This transition included going from hand production methods to machines, new chemical manufacturing and iron production processes, the increasing use of water power and steam power, the development of machine tools, and the rise of the mechanized factory system. The output greatly increased, resulting in

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an unprecedented rise in population and population growth. The precise start and end of the Industrial Revolution are debated among historians, as is the pace of economic and social changes. (Hall, 2024). According to Cambridge University professor Leigh Shaw-Taylor, Britain was already industrializing in the 17th century. (Taylor, 1951) Hobsbawm asserted that the Industrial Revolution in Britain occurred in the 1780s, with its effects becoming fully apparent by the 1830s. (Hobsbawm,1962). Rapid adoption of mechanized textile spinning occurred in Britain in the 1780s, and high rates of growth in steam power and iron production occurred after 1800. Mechanized textile production spread from Britain to continental Europe and the US in the early 19th century. (Rosen, 2012).

Revolution 2.0: The Second Industrial Revolution

The Second Industrial Revolution was characterized by a period of accelerated industrial development, predominantly in the United Kingdom, Germany, and the United States, with significant advancements also observed in France, Italy, Japan, and the Low Countries. It followed the First Industrial Revolution, which flourished in Britain in the late 18th century and then spread throughout Western Europe. It came to an end with the start of World War I (1914) (Richard, 2022). While the First Revolution was driven by the limited use of steam engines, interchangeable parts, and mass production, and was largely water-powered, especially in the United States, (Hounshell, 1984), the Second featured the build-out of railroads, large-scale iron and steel production, widespread use of machinery in manufacturing, greatly increased use of steam power, widespread use of the telegraph, use of petroleum, and the beginning

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of electrification. Education played a role, and modern organizational methods for operating large scale businesses over vast areas were adopted (Penprase, 2018).

Revolution 3.0: The Third Industrial Revolution

The Information Age is a historical period that began in the mid-20th century. It is characterized by a rapid shift from traditional industries, as established during the Industrial Revolution, to an information technology-centered economy. The outset of the Information Age has been linked to the development of the transistor in 1947 (Manuel, 1996). This technological advance has significantly impacted the way information is processed and transmitted. Digital communication became economical for widespread adoption after the invention of personal computers in the 1970s. Claude Shannon, a Bell Labs mathematician, is generally credited with laying the foundations of digitalization in his pioneering 1948 article, *A Mathematical Theory of Communication*. (Shannon & Weaver, 1963).

Revolution 4.0: The Fourth Industrial Revolution

Fourth Industrial Revolution was first introduced by a team of scientists developing a high-tech strategy for the German government. Klaus Schwab, former executive chairman of the World Economic Forum (WEF), introduced the phrase to a wider audience in a 2015 article published by Foreign Affairs. (Schwab, 2015) "Mastering the Fourth Industrial Revolution" was the 2016 theme of the World Economic Forum Annual Meeting, in Davos-Klosters, Switzerland. The Fourth Industrial Revolution has been

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defined as technological developments in cyber-physical systems, such as high-capacity connectivity; new human-machine interaction modes, such as touch interfaces and virtual reality systems; and improvements in transferring digital instructions to the physical world, including robotics and 3D printing (additive manufacturing), big data, and cloud computing; improvements to and uptake of off-grid solar, wind, wave, hydroelectric, and electric batteries (lithium-ion renewable energy storage systems and EV) (Sharma & Bikram, 2020).

The Fourth Industrial Revolution is driven by a network of interconnected digital technologies that integrate physical production with intelligent computational systems. According to Sharma and Bikram (2020), these technologies collectively define the operational framework of Industry 4.0 and distinguish it from earlier industrial revolutions. Central among these technologies is the Internet of Things (IoT), which refers to the connection of sensors and devices to the Internet for communication and data exchange. Closely related to this is the Industrial Internet of Things (IIoT), which emphasizes the integration of suppliers, machines, computers, and industrial data within manufacturing and production systems. Another major component of Industry 4.0 is big data, which involves the collection, storage, organization, and analysis of large volumes of structured and unstructured data to identify patterns, trends, and operational possibilities of the data. This process is enhanced by artificial intelligence (AI), which enables machines and computer systems to perform tasks that traditionally require human intelligence to perform. Similarly, machine-to-machine (M2M) communication facilitates automated interactions between devices through wired or wireless

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networks, thereby improving industrial efficiency and coordination. Industry 4.0 is significantly reliant on digitization, which entails the transformation of information and operational processes into digital formats to facilitate enhanced storage, accessibility, and transmission. Furthermore, machine learning enables computer systems to enhance their performance and decision-making capabilities by analyzing data, eliminating the need for explicit programming for each task. These advancements are bolstered by cloud computing, which offers internet-based storage, management, and processing of data across multiple servers. In addition, the capability of processing data in real time allows machines and computer systems to continuously evaluate and react to information with near-instant speed. Together, these technologies function within an industrial ecosystem that merges manufacturing, procurement, supply chain management, customer service, and cyber-physical systems into a cohesive digital production structure. These linked advancements signify a major shift in how production, communication, and industrial management are organized, as embodied by Industry 4.0.

The Longue Durée of Technological Development and the African Pre-Colonial Context

To engage in a rigorous historical analysis of the Fourth Industrial Revolution (4IR) in Africa, one must first dismantle the prevailing narrative that the continent's technological history began with external interventions. (Balbi et al., 2021) Scholarly research indicates that the digital age did not arrive in a vacuum; it grew from roots that extend deep into the "analogue" era and, further back, into ancient African scientific traditions. Archaeological findings reveal that Africa was a

cradle of technological, mathematical, and geometrical innovation long before the first global industrial shifts. One of the earliest examples is the Oldowan tool-making industry of eastern Africa, which emerged approximately 2.3 million years ago and represents some of the earliest known evidence of systematic technological production by early hominin. This trajectory of indigenous innovation continued through later developments such as the Lebombo bone, discovered in the mountains between Swaziland and South Africa and dating to approximately 35,000 BCE. Featuring 29 distinct notches, the artifact suggests an early understanding of tallying and possibly lunar cycles (Levtzion, 1977). These advancements were further reflected in the sophisticated metallurgical practices that later emerged across West and Central Africa. Shillington (2005) explains that modern man first developed in the Great Rift Valley of Africa, where the first development of tools was found. Homo ergaster developed the Acheulean stone tool industry, specifically hand axes, in Africa in 1.5 million BC. This tool industry spread to the Middle East and Europe around 800,000–600,000 BC. Homo erectus began using fire. Homo sapiens sapiens or modern humans created bone tools and back blades around 90,000 to 60,000 BC in Southern and Eastern Africa. The use of bone tools and back blades became characteristic of later stone tool industries. These historical precursors are essential for contextualizing the 4IR, as they demonstrate that the African continent possesses a foundational heritage of technical praxis that was systematically disrupted by the structural asymmetries of the first three industrial revolutions.

The transition from these indigenous systems to modern industrial paradigms was not linear but involved a series of ruptures. The First

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Industrial Revolution spanned from approximately 1760 to 1840. Triggered by the construction of railroads and the invention of the steam engine, it ushered in mechanical production. The Second Industrial Revolution, which started in the late 19th century and continued into the early 20th century, made mass production possible, fostered by the advent of electricity and the assembly line. The Third Industrial Revolution began in the 1960s. It is usually called the computer or digital revolution because it was catalyzed by the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 80s) and the Internet (1990s). Historical analysis suggests that the first (1IR) and second (2IR) industrial revolutions in the Global North were inextricably linked to the colonization of Africa. While the 1IR (1750–1850) focused on steam power and mechanization and the 2IR (1850–1914) introduced electricity and mass production, their impact on Africa was primarily extractive. (Schwab, 2016). Colonial powers utilized these technological advancements to facilitate the looting of African resources, establishing extractive infrastructures such as railroads designed solely to transport minerals and agricultural commodities from the hinterland to seaports for shipment to European metropolises. This era saw the erosion of African human capital through slavery and the suppression of indigenous innovation, creating a path dependency that continues to influence Africa's technological response in the 21st century (Ndikumana, 2022).

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The Colonial Contract and the Structural Failure of Import Substitution

The post-independence period in the late 1950s and the 1960s offered a glimpse of potential industrial sovereignty, yet it was largely constrained by the "colonial contract" a set of lingering economic and political ties that favoured the former colonizers (Marivate et al., 2021) African nations identified industrialization as a primary means of achieving economic independence, leading to the widespread adoption of Import Substitution Industrialization (ISI) (Diallo, 2025). This strategy, which gained momentum in countries such as Tanzania, Zambia, and Nigeria during the 1960s, sought to create domestic manufacturing bases to replace expensive imports from the Global North (Mendes et al., 2014). However, historical research demonstrates that ISI often sowed the seeds of its own destruction. African industries were frequently established with heavy protection and a reliance on imported machinery, making them poorly prepared for international competition (Brookings Institution, n.d.). The lack of a skilled human resource base, coupled with poor terms of trade and governance challenges such as corruption, plunged many of these early industrial efforts into a "vicious cycle of underdevelopment" (Ndikumana, 2022).

The failure of ISI was exacerbated by the subsequent "Structural Adjustment" phase of the 1980s and the 1990s. International financial institutions mandated trade liberalisation and privatisation, which often led to the collapse of nascent African manufacturing firms that could not compete with established global actors (Brookings Institution, n.d.). During this period, Sub-Saharan Africa's average share of manufacturing value added in GDP remained virtually

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unchanged from the 1970s, hovering around 10 percent, while other regions like East Asia achieved massive industrial catch-up. This historical inertia meant that as the world transitioned into the Third Industrial Revolution (3IR) of computers and digitalization, Africa remained largely a consumer rather than a producer of technology. The legacy of these failed models underscores a critical lesson for the 4IR: technological adoption without political and economic autonomy or "epistemic freedom" risks perpetuating historical marginalization (Benyera, 2022).

Defining the Fourth Industrial Revolution in the African Context

The Fourth Industrial Revolution (4IR) is distinct from its predecessors in its fusion of the digital, physical, and biological worlds (Marr, 2019). While the 3IR was defined by computers and the Internet, the 4IR is characterized by cyber-physical systems, artificial intelligence (AI), robotics, the Internet of Things (IoT), and advanced wireless technologies (Ndung'u & Signé, 2020). It is the fusion of these technologies and their interaction across the physical, digital, and biological domains that makes the Fourth Industrial Revolution fundamentally different from previous revolutions. For Africa, the 4IR is often debated as a "cure-all" for contemporary challenges or a "curse" that could deepen existing inequalities. Proponents argue that the 4IR offers a "leapfrog" opportunity, allowing African nations to bypass traditional, resource-heavy industrial phases and move directly toward a knowledge-based, service-oriented economy. This is evidenced by the "Digital Awakening" currently occurring across the

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continent, where innovations in mobile money and drone delivery are addressing long-standing service delivery gaps (Marr, 2019).

However, the "materiality" of the Fourth Industrial Revolution (4IR) remains contested. Some scholars argue that the 4IR is merely an acceleration of the 3IR's digital foundations, while others contend it represents a radical reshaping of human existence through the appropriation of social life via data extraction (Marivate et al., 2021). In the African context, the 4IR is not value-neutral; it is often embedded with the worldviews and norms of its designers in Euro-America or China. This leads to the phenomenon of "techno-colonialism," where foreign technologies are transferred to Africa along with external cultural and social values that may conflict with local traditions such as Ubuntu (Ugar, 2023). The pursuit of epistemic freedom, the ability for Africa to define its own technological trajectory and safeguard its human, natural, and financial capitals is therefore a prerequisite for ensuring that the 4IR contributes to genuine development rather than recolonization (Alozie, 2008).

The Infrastructure Paradox: Connectivity, Energy, and the Usage Gap

The implementation of the 4IR in Africa is hampered by a significant infrastructure paradox. Although mobile digital financial services have expanded rapidly across the continent, resulting in Africa accounting for nearly half of all global mobile money accounts, the continent's fundamental physical infrastructure remains severely underdeveloped (Ndung'u & Signé, 2020). Approximately 600 million

Africans, representing nearly half of the continent's population, lack access to electricity, which is essential for digital growth (Mohammed, 2025). Furthermore, while 84 percent of Sub-Saharan Africans live in areas covered by 3G networks and 63 percent have access to 4G services, only about 22 percent were actively using mobile internet services as of late 2021. This "usage gap" is largely driven by the high cost of data, which averaged 10.5 percent of monthly per-capita GNI in 2019, as well as the prohibitive cost of internet-enabled devices (World Bank Group, 2024).

This digital divide replicates the existing socioeconomic fault lines. The Digital Economy Readiness (DER) index shows that participation in the 4IR is highly uneven, with high readiness in countries like Mauritius and Morocco contrasted by extremely low readiness in Malawi and Madagascar (Van Wyk-Khosa et al., 2025). Structural factors like unreliable power grids and limited access to personal computers mean that most Africans access the internet via smartphones, which are often inadequate for high-level digital services such as software design or complex collaboration. Without addressing these basic necessities, African governments risk relegating their citizens to the role of "passive consumers" in the 4IR, rather than active participants and producers of digital goods (Van Wyk-Khosa et al., 2025).

Innovation Landscapes and the R&D Spending Deficit

A scholarly analysis of Africa's innovation landscape reveals a stark discrepancy between the continent's potential and its actual research output. In 2021, Africa possessed only 821 researchers per million inhabitants, a figure significantly lower than the global average of

1,352 and far behind Europe and North America, which exceed 4,000. While researcher density grew by 149 percent between 2010 and 2021, it remains insufficient to close the projected 91 percent innovation gap by 2030 (United Nations, n.d.). This deficit is directly linked to low levels of investment; Africa's gross domestic expenditure on research and development (GERD) averaged only 0.52 percent of GDP in 2022, well below the global average of 1.95 percent. Only Egypt has managed to meet the African Union's target of investing 1.0 percent of GDP in R&D (United Nations, n.d.).

The lack of domestic innovation is reflected in the intellectual property (IP) statistics. In 2023, Africa accounted for just 0.6 percent of the world's patent applications, with over 80 percent of those filed within Africa originating from foreign entities. This suggests that the 4IR in Africa is currently being "architected" elsewhere, with the continent serving primarily as a laboratory for testing and a market for consumption. However, leading countries like Morocco and South Africa are showing signs of progress in medium and high-tech (MHT) industries, with Morocco's MHT share in manufacturing value added reaching 37.5 percent. To transition from a laggard to a leader, African states must redouble their efforts to invest in STEM education and foster a robust IP ecosystem that incentivizes local R&D (United Nations, n.d.).

Sectoral Revolutions: Fintech, Agtech, and Health

The 4IR's most tangible impacts in Africa are observed in specific sectoral transformations that leverage the continent's mobile-first environment. In the financial sector, Africa is a global leader in mobile

money, with service-trade worth $68 billion in Kenya alone during 2023 (Mohammed, 2025). Mobile technologies have become a major driver of economic activity in Sub-Saharan Africa, generating approximately 1.7 million direct jobs and contributing around $140–144 billion in economic value, or about 8–9 percent of regional GDP (GSMA, 2023). Beyond payments, AI tools are helping customize financial services for the unbanked, while blockchain technology reduces fraud and risk costs in cross-border lending. However, this digitalization has also made the financial sector a primary target for cyberattacks, emphasizing the need for robust cybersecurity infrastructure as a pillar of national 4IR strategies (Fox & Signé, 2022).

Agriculture, which employs 60 percent of the Sub-Saharan African labor force, is also undergoing a 4IR-driven metamorphosis. Startups like Aerobotics in South Africa are using drones and machine learning to optimize crop yields and mitigate climate risks. IoT-enabled sensors allow farmers to manage soil health and track supply chains more effectively, which is critical for a continent where the food system is projected to add more jobs than any other sector between 2010 and 2026. In health care, Rwanda's use of Zipline drones to deliver blood and medicine to remote clinics has reduced delivery times by 99 percent, demonstrating how autonomous systems can bridge the "last-mile" gap in fragile states (Ndung'u & Signé, 2020).

Human Capital, Labour Dynamics, and the 2030 Horizon

The future of the 4IR in Africa is inextricably linked to human capital. By 2030, Africa's potential workforce will be among the world's largest, and the share of workers with at least a secondary

education is set to increase to 52 percent from 36 percent in 2010 (Ndung'u & Signé, 2020). This demographic shift represents a massive opportunity, but it also poses a risk of social disruption. Some 4IR technologies tend to replace low-skilled workers with higher-skilled labour, which could constrain participation to economies with relevant technical competencies. Research suggests that 4IR could create 133 million jobs globally by the end of 2022 but displace 75 million, a net gain that may not be evenly distributed in African contexts where informal labor still predominates (Fox & Signé, 2022).

To mitigate the risk of widening inequality, African higher education institutions must undergo a "radical transformation" toward a University 4.0 model. This involves updating curricula to reflect the demands of the digital economy and fostering partnerships between academia and industry stakeholders to ensure graduates possess employability skills. There is also a call for the decolonization of the curriculum, integrating local knowledge systems into modern (Samuels & Singh, 2025). STEM education to ensure that the 4IR is built on an African cultural and epistemic foundation. Without these interventions, the 4IR could replicate the historical errors of the 1IR and 2IR, where the continent's human capital was exploited rather than empowered (Ndikumana, 2022).

Data Colonialism and the Sovereignty of Information

One of the most critical risks of the 4IR for Africa is the emergence of "data colonialism" or the "coloniality of data". In this new phase of capitalism, social life is appropriated through massive data extraction, with data serving as the primary capital for global tech multinational corporations. Historical analysis suggests that just as colonial powers

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once mined African minerals, modern "global cartels" are now mining African data, often in the absence of strong national regulatory institutions to oversee this extraction (Benyera, 2021). This has profound implications for sovereignty; as coloniality outlives traditional decolonization, it positions itself as the custodian of African data, potentially excluding African people from the realm of knowledge production once again. For Africa to turn the 4IR into a resource rather than a curse, it must assert its "digital self-determination" (Ifegwu-Mbonu, 2024). This requires owning strategic government data and securing citizen information to prevent it from being harvested without benefit to the continent (Gillwald, 2020). Efforts like the Smart Africa Trust Alliance (SATA) are vital in this regard, as they seek to create a secure environment where persons can prove their identities across a single digital market, ensuring that the benefits of the data revolution remain within African borders (Smart Africa, 2022).The historical lesson remains: he who controls the information and the tools of its production controls the economy (Benyera, 2021).

Synthesis and Strategic Directives for the 4IR Era

A comprehensive historical analysis reveals that Africa's journey through the first three industrial revolutions was characterized by structural exclusion and the distortion of indigenous innovation systems (Ugar, 2023). Epistemic freedom in this context is expressed through the ability of African societies to determine the production, validation, and direction of knowledge systems. Historically, African integration into global industrial processes has been shaped by externally defined epistemologies, resulting in dependency in

innovation theory and curriculum structures that privilege imported technological paradigms over indigenous knowledge systems (Ugar, 2023). This limits Africa's capacity to generate autonomous technological pathways within the 4IR.

Digital sovereignty, on the other hand, concerns control over data infrastructures, digital platforms, and value extraction within the digital economy. The current global digital order is characterised by asymmetric control of data flows by multinational technology corporations, resulting in Africa's role as a producer of raw data but not its primary economic beneficiary (Gillwald, 2020). This creates a structural imbalance in ownership, regulation, and monetisation of digital resources. Institutional capacity refers to the effectiveness of African governance systems in regulating and shaping technological transformation. Weak regulatory environments, fragmented policy coordination, and implementation gaps continue to limit the translation of digital technologies into productive developmental outcomes, even where infrastructure exists (Ndikumana, 2022). The 4IR represents a pivot point where the continent can either succumb to a "recolonization" driven by data and techno-colonialism or reclaim its economic sovereignty through active architecture and epistemic freedom. To achieve the latter, the analysis identifies several strategic imperatives for African leaders, policymakers, and private sector actors.

First, there is an urgent need to bridge the "usage gap" in digital infrastructure in rural areas. Simply expanding mobile coverage is insufficient if data remain unaffordable and electricity access is limited (World Bank Group, 2024). Governments must prioritize investment in the "middle and last mile" of digital infrastructure and implement

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laws to maintain affordable data prices (Brookings Institution, n.d.). Second, the revitalization of the education system is critical. Africa must move from being a source of raw talent for global markets to a hub for domestic innovation by embedding 4IR skills into vocational and tertiary curricula.

Third, the protection of African "data sovereignty" is essential. The unregulated mining of African data by global corporations is a 21st-century form of extraction that must be managed through strong national and regional regulatory frameworks (Benyera, 2022). Fourth, the AfCFTA should be leveraged as a "deal-maker" for the youthful population, facilitating the trade of digital and green services and providing the scale necessary for African innovators to compete globally. Finally, the 4IR must be rooted in African philosophical traditions such as Ubuntu and Maathai's ecological framework, ensuring that technological advancement does not come at the cost of communal harmony or environmental integrity (Smart Africa, 2022). Only through such culturally grounded and politically autonomous approaches can Africa transform the 4IR from a potential curse into a sustainable resource for its people.

Through these coordinated efforts, the "sleeping giant" that is the African continent can transition from the peripheral position it occupied during the 1IR, 2IR, and 3IR to a leading role in parts of the Fourth Industrial Revolution. The historical trajectory suggests that while the starting line is behind, the determination and unique demographic strengths of the continent provide a path toward becoming a global 4IR powerhouse (Mohammed, 2025).

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Conclusion

This historical analysis shows that Africa's experience of successive industrial revolutions has been uneven and structurally constrained. This pattern is largely shaped by colonial legacies, unequal integration into the global economy, and persistent limitations in technological capacity, institutional development, and human capital formation. From the First Industrial Revolution through the Third, Africa was primarily integrated into the global system in a peripheral and extractive role. These historical conditions have continued to shape the continent's position in the Fourth Industrial Revolution (4IR), reinforcing patterns of dependency and uneven development. From the First Industrial Revolution through the Third, Africa's role was largely extractive and peripheral, reinforcing dependency patterns that continue to influence its position within the Fourth Industrial Revolution (4IR). The emergence of Fourth Industrial Revolution (4IR) technologies, artificial intelligence, big data, the Internet of Things, and cyber-physical systems presents both a transformative opportunity and a profound risk. On the one hand, these technologies offer the possibility of leapfrogging traditional developmental stages, enhancing productivity, and addressing structural challenges in finance, agriculture, and healthcare. However, without deliberate policy intervention, they risk reproducing historical inequalities through new forms of dependency, particularly via data colonialism, infrastructural deficits, and external control over technological ecosystems.

A central finding of this analysis is that technology adoption alone is insufficient to ensure development. Africa's ability to benefit from the 4IR is contingent on achieving epistemic freedom, strengthening

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digital sovereignty, and building robust institutions capable of regulating and shaping technological systems in alignment with African socio-cultural and developmental priorities. The persistence of the digital divide, low investment in research and development, and limited innovation capacity underscore the urgency of strategic investments in education, infrastructure, and indigenous knowledge systems. Regional initiatives, such as the African Continental Free Trade Area (AfCFTA), Smart Africa framework, and emerging standardization strategies, provide critical platforms for coordinated industrial and digital transformation. If effectively implemented, these efforts can enable Africa to build integrated digital markets, enhance intra-African trade, and negotiate more equitably within global technological value chains. However, their success depends on strong political commitment, regulatory coherence, and sustained investment in human and institutional capacity.

Ultimately, Africa's trajectory in the Fourth Industrial Revolution will be determined by its ability to transition from passive consumption to active production of technology. This requires a paradigm shift toward inclusive, sustainable, and Africa-centered development models grounded in principles such as Ubuntu and ecological stewardship. If these conditions are met, the 4IR can serve not as an instrument of recolonization but as a catalyst for structural transformation, economic sovereignty, and long-term sustainable development across the continent.

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