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Digitalization and the Application of Artificial Intelligence in Priority Sector among Resource-Endowed African Countries

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Abstract

Digitalization and artificial intelligence possess significant potential to enhance the inefficient utilization of natural resources. Nonetheless, research on this subject remains limited in many resource-abundant African nations. This study draws upon economic growth theory, which posits that AI can serve as a substitute for conventional factors of production and foster the generation of innovative ideas, thereby facilitating long-term growth trajectories. The results indicate that digital initiatives in resource-rich African countries predominantly concentrate on sectors such as financial technology, agriculture, manufacturing, public services, healthcare, education, and general service provision, while largely neglecting their primary resource industries, including oil, gas, and minerals. Notably, South Africa has prioritized the integration of digital technologies within its mining sector. Overall, the adoption of AI across Africa is still in a nascent stage, even among countries endowed with substantial resources. However, nations like Algeria, South Africa, and Zimbabwe have demonstrated some progress in implementing AI solutions within their petroleum and mining industries. The study recommends that other resource-rich African countries intentionally incorporate digital technologies and AI into their resource sectors to improve efficiency, enhance competitiveness, and boost productivity.

Keywords: Digitalization; Artificial Intelligence; Priority Sector; Resource-Endowed; African Countries

1. Introduction

Digitalization is revolutionizing all domains of science and serves as a strategic resource to enhance policymaking and foster innovation (OECD, 2020). There is an observable upward trend among developed nations to adopt digital technologies and artificial intelligence (AI) (Aditya, 2022). The convergence of digitalization and AI has amplified human capabilities and improved efficiency across diverse economic sectors, resulting in increased profit margins (Hiremath et al., 2023). Consequently, digitalization and AI are increasingly regarded as indispensable tools rather than optional enhancements (Schneider & Kokshagina, 2021).

AI functions as a principal catalyst of transformation, inducing disruptions that enable enterprises to maintain competitiveness within a rapidly changing global economy. Numerous countries are progressively integrating digitalization and AI into their industrial frameworks to secure strategic advantages. Industries such as manufacturing, healthcare, and agriculture are witnessing a surge in AI-driven applications aimed at optimizing efficiency, reducing operational costs, and stimulating innovation (UNIDO, 2024). As technological advancements persist, the integration of AI across various sectors is becoming critical for achieving sustainable development and economic growth (UNIDO, 2024). The COVID-19 pandemic has further expedited this transition, compelling many sectors to adopt new operational models, including widespread remote working arrangements and increased reliance on online communication and educational tools (Aditya, 2022).

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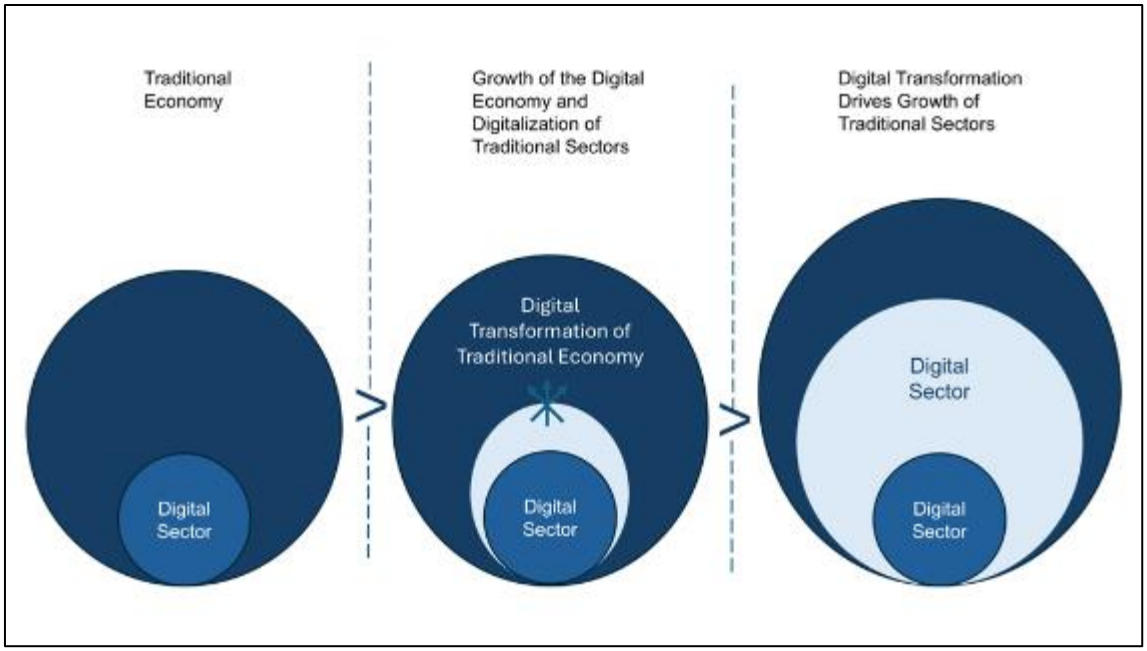
Few studies have explicitly attempted to define digitalization or identify its core characteristics. For instance, Reis et al. (2020) provided a broad overview of various definitions originating from disciplines such as communication, science, and technology. However, within the context of this research, only select definitions were considered. One such definition by Amit and Zott (2001) characterizes digitalization as "one of the most significant ongoing transformations of modern society, impacting numerous aspects of business and daily life. It involves the shift from analog to digital formats such as transitioning from cash transactions to electronic payments and facilitates new value creation methods, including enhanced accessibility, availability, and transparency." Perez (2015) conceptualized digitalization not merely as a disruptive revolution but as the pervasive integration of digital innovations throughout the economy and society. The International Energy Agency (2017) defined digitalization as the increasing adoption of information and communication technologies (ICT) across economic sectors, encompassing emerging technologies and trends such as artificial intelligence, the Internet of Things, and the Fourth Industrial Revolution.

This dynamic digital economy comprises both digital industrialization and industrial digitalization. Digital industrialization primarily pertains to developments within the information sector, whereas industrial digitalization aims to modernize and transform existing industrial operations (see Li, 2023). Similarly, artificial intelligence (AI) is generally understood as "the study of theories, techniques, tools, and application systems that mimic, extend, and enhance human intelligence" (Li, 2023). Its overarching objective is to comprehend intelligence and develop machines capable of exhibiting human-like behaviors. The progression of AI involves various tasks, including language recognition, image recognition, natural language processing, expert systems, and robotics.

The World Bank (2020b) emphasizes the vital role of digital technology in reforming and enhancing the growth of traditional sectors across all economies. Fundamentally, utilizing digital tools is essential for transforming a conventional economy into one characterized by swift development, poverty alleviation, and heightened competitiveness, propelled by the dynamic influence of a vibrant digital sector, as illustrated in Figure 1.



Source: World Bank (2020b).

Figure 1 Economic Impact of Digitalization in an Economy

Africa possesses vast deposits of natural resources, including gold, oil, natural gas, coal, platinum, chromium, aluminum, zinc, lithium, and other valuable minerals. The continent contains nearly all the essential minerals necessary for economic development, manufacturing, and technological advancement. It holds approximately 30% of global mineral reserves (Okafor, 2024). Nations such as South Africa, Nigeria, Algeria, Angola, and Libya collectively represent over two-thirds of Africa's mineral wealth, primarily due to their significant oil reserves, with South Africa distinguished for its gold and other precious metals. The considerable revenue potential derived from royalties, rents, and high commodity prices for resources like copper, oil, iron ore, aluminum, and gas are anticipated to attract investment, improve external balance, stabilize national currencies, and promote overall economic growth and development.

Table 1 Top Ten Resource-Endowed African Countries

Country Ranking		Predominant Resources	Annual Mineral Production (US$)
1	South Africa	Gold, Manganese, Platinum, others	$124.9 billion
2	Nigeria	Oil, Iron Ore, Columbite, others	$52.69 billion
3	Algeria	Hydrocarbons	$38.70 billion
4	Angola	Diamond, Gold, Oil, others	$32.04 billion
5	Libya	Oil, Clay, Cement, Salt, others	$27.03 billion
6	Egypt	Gold, Copper, Silver, others	$23.22 billion
7	Ghana	Gold, Limestone, Iron Ore, others	$14.97 billion
8	D. R. Congo	Gold, Copper, Cobalt, others	$13.69 billion
9	Gabon	Manganese, Iron Ore, Uranium, others	$10.92 billion
10	Zimbabwe	Platinum, Chrome, Coal, Gold, others	$9.77 billion

Source: Ashcroft (2024); Okafor (2024)

Consequently, the mining and oil sectors are regarded as primary areas of emphasis within Africa due to their substantial capacity to contribute to the economic revenue of various nations, as demonstrated in Table 1 above.

Despite possessing substantial reserves of these abundant natural resources, Africa has yet to attain the level of growth and development necessary to enhance the living standards of its large population (Adekunle et al., 2023). Countries in Africa endowed with significant natural resources include South Africa, Nigeria, Algeria, Angola, Libya, Egypt, Ghana, the Democratic Republic of Congo, Gabon, and Zimbabwe (see Ashcroft, 2024). Nevertheless, in spite of these resource endowments, these nations continue to confront challenges such as poverty, illiteracy, inadequate infrastructure, corruption, conflict, unemployment, and pronounced inequality (Adekunle et al., 2023; Musibau et al., 2022).

It is commonly anticipated that the presence of rich natural resources would confer a competitive advantage, laying a foundation for rapid economic transformation, growth, and development akin to the experiences observed in Middle Eastern countries. In those regions, resource wealth has been exploited to stimulate economic expansion and elevate living standards, thereby significantly reducing poverty levels.

Empirical evidence suggests that numerous African countries are affected by the resource curse, a phenomenon characterized by the inability of resource-rich nations to fully capitalize on their natural resources and for governments to effectively address public welfare needs (Muigua et al., 2015). This paradox, often referred to as the paradox of plenty, indicates that countries endowed with abundant raw materials frequently exhibit lower GDP per capita and poorer development outcomes compared to nations with fewer natural resources (Henri, 2019).

The resource curse generally refers to the paradox whereby countries endowed with abundant natural resources experience sluggish economic growth and poor management of resource revenues (see Demissie, 2024; Mulwa & Mariara, 2016; Nurmakhanova et al., 2023; Inuwa et al., 2024; Muigua, 2024; Tsopmo et al., 2024). This phenomenon often leads to inefficient allocation and inequitable distribution of resource-derived income, thereby impeding sustainable development and economic progress across the continent (Mailey, 2015; Muigua, 2024). Recent scholarly investigations indicate that digital transformation and artificial intelligence technologies hold potential for mitigating the resource curse by enhancing resource management practices (see Mai et al., 2022; Chang et al., 2023; Li et al., 2023; Lee et al., 2024; Musonda, 2024; Rasheed et al., 2024; Shang et al., 2024; Tao, 2025; Xu et al., 2024). Nonetheless, there remains a notable research gap concerning the application of these technological innovations within the African context, particularly among resource-rich nations. Although some limited studies have examined how certain countries are experimenting with digital and AI innovations, these efforts have generally not been specifically focused on leveraging their resource endowments (see Ogunleye, 2021; Musonda, 2024).

The adoption of digital technologies and artificial intelligence continues to expand across various industries and sectors globally (see OECD, 2020). This progression is primarily propelled by ongoing globalization among nations and aligns closely with the African Union's 2063 agenda, which seeks to leverage digital innovations to generate employment, alleviate poverty and inequality, and enhance the exchange of goods and services across the continent. These initiatives

contribute to the broader objectives of sustainable development. The primary aim of this research is to enhance understanding of the deployment of digital technology and AI within the African context. In particular, it intends to evaluate the extent of digitalization among resource-rich African nations and to analyze the sector-specific applications of AI, considering each country's resource endowments. The study is structured into multiple sections: a literature review in section two, research methodology in section three, an assessment of digitalization levels in resource-abundant African countries in section four, and discussions concerning the sectoral deployment of AI in sections five and conclusion in section six.

2. Literature Review

An empirical investigation by Butt (2024) examined the deployment of artificial intelligence in public administration across Nordic nations and other European countries. The study utilized both quantitative and qualitative methodologies to discern patterns, tendencies, and correlations in AI adoption across various regions and sectors. Results indicated that Denmark exhibits the highest level of e-government engagement, with a utilization rate of 110%, followed by Cyprus at 100%, and Finland at 99%. Furthermore, the research identified Finland as having the greatest number of AI specialists, with a ratio of 22 per 10,000 enterprises, with Sweden and the Netherlands trailing at 18 and 16 respectively. Concerning digital public services available to businesses, Finland, Estonia, Malta, and Luxembourg were recognized as leaders. The Digital Economy and Society Index, which underscores developments in human capital, ranked Finland and Denmark at the forefront, with the Netherlands, Sweden, and Ireland positioned subsequently.

Similarly, Hiremath et al. (2023) investigated the primary determinants influencing digitalization and AI integration within India's retail industry. Employing a qualitative research approach, the study concluded that the sector's performance is predominantly shaped by factors that promote digitalization in food and grocery retailing. These factors include operational convenience, the adoption of digital payment platforms, enhanced internet connectivity, improved interactions between retailers and consumers, and the integration of AI technologies. Additionally, Priyadi and Arwani (2024) examined digital transformation and artificial intelligence's role in shaping the future of the public sector through a comprehensive literature review. Their findings suggest that AI holds significant potential to improve financial processes within government agencies. They emphasize that digitalization initiatives such as automation, reduction of human errors, and enhanced decision-making are heavily reliant on effective data management systems.

Equally, Li (2023) investigated the relationship between artificial intelligence and enterprise digital transformation using both qualitative and quantitative approaches. The findings indicated that 91% of organizations are engaged in digital initiatives, with 87% of CEOs prioritizing digitalization efforts. This trend was further accelerated by the COVID-19 pandemic, during which 37% of companies adopted remote work arrangements to maintain operations. Currently, more than 89% of firms globally have implemented digital strategies to enhance their product outreach to potential consumers. Looking forward, enterprises are expected to increasingly depend on AI tools for data analysis and trend forecasting, thereby facilitating more informed and strategic decision-making processes.

In the African context, there is a rising interest among researchers and policymakers in the fields of digitalization and artificial intelligence. For instance, Molossi and Pipan (2023) conducted a study employing image logs and cutting-edge AI techniques to mitigate drilling hazards, primarily in East Africa. By leveraging AI to analyze and interpret image logs, they developed an innovative method to automate data processing and improve borehole stability, ultimately reducing drilling risks. Additionally, Vernon (2019) examined the potential applications of robotics and AI within Africa, highlighting their capacity to promote social and economic development. The study advocates for African nations to capitalize on opportunities for intelligent automation provided by AI advancements to enhance efficiency and competitiveness, while also addressing global challenges such as early deindustrialization.

Furthermore, Kondo and Diwani (2023) provided a comprehensive overview of artificial intelligence applications, emphasizing their potential to serve as a transformative force across various sectors. AI has the capacity to act as a catalyst for enhancing human capabilities and addressing societal challenges in fields such as healthcare, infrastructure, the digital economy, environmental conservation, and agriculture. In contrast, Musonda (2024) investigated the utilization of AI in the management of natural resources in Africa, with particular attention to mining and healthcare sectors. The study confirms that AI holds the promise of revolutionizing mineral exploration through advanced mapping and remote sensing technologies, thereby reducing mining costs and increasing operational efficiency. It also underscores AI's advantages in healthcare, especially in diagnostic processes and the deployment of drones for medical logistics. Notably, the research indicates that AI is already being implemented in Zambia for tuberculosis screening and treatment initiatives.

Additionally, Tao (2025) analyzed the role of AI in enhancing global green productivity among 59 countries. The study employed multiple estimation techniques, including panel fixed effects, random effects, feasible generalized least squares, and system GMM. Findings demonstrated that AI significantly contributes to the improvement of green productivity in the nations studied. Meanwhile, Rasheed et al. (2024) examined the relationship between AI and renewable energy production in 22 leading robotics and innovation-driven countries. Their non-linear ARDL panel analysis revealed that AI exerts a strong positive influence on renewable energy output over the long term.

Likewise, Samuel-Okon and Abejide (2024) investigate the potential of artificial intelligence (AI) and automation to reduce the digital divide in developing nations, emphasizing their role in enhancing accessibility and efficiency in critical sectors such as education, healthcare, agriculture, and economic development through a mixed methods approach. Their results indicate that AI and automation can substantially improve education by providing personalized learning experiences, advance healthcare through improved diagnostics and patient management, increase agricultural productivity via precision farming techniques, and foster economic development by generating new employment opportunities.

In the Asian context, Yu and Liu (2024) conducted a study on the impact of digitalization on carbon productivity across 136 countries, utilizing a panel fixed effects model. Their findings reveal that digitalization significantly elevates carbon productivity primarily through technological innovation. Concurrently, Xu et al. (2024) examined the influence of digital governance on the efficiency of natural resource management across 262 Chinese cities, concluding that digital governance enhances natural resource efficiency. This improvement is mediated through increased government performance, expanded regional digital infrastructure, and progress in regional and green innovation initiatives.

In 2022, Mai conducted an empirical investigation into the relationship between digitalization and natural resource utilization across 26 European nations, employing the panel corrected standard error (PCSE) model and feasible generalized least squares methods. The results demonstrated that digital enterprises and digital public services generally contribute to an increase in overall resource rents. Specifically, digital activities were found to significantly elevate rents derived from coal, minerals, natural gas, and forests. Conversely, Li et al. (2023) examined the influence of financial technology, digitalization, institutional quality, and human capital on natural resource rents within selected OECD countries. They utilized a range of regression techniques, including moment quantile regression, fully modified least squares, panel fixed effects, and panel dynamic least squares. Their findings indicated that advancements in financial technology, digitalization, human development, and robust institutional frameworks are associated with a reduction in dependence on natural resources. However, the study also identified that digitalization may lead to a substantial increase in resource rents beyond a certain threshold.

Furthermore, Shang et al. (2024) analyzed the roles of energy efficiency and artificial intelligence (AI) in promoting carbon neutrality in specific Chinese industries. Their research suggested that integrating AI through robotics facilitates both immediate and long-term carbon emission reductions, thereby supporting sustainable AI development alongside industrial growth. In Nigeria, Ogunleye (2021) explored AI as a catalyst for economic development, emphasizing its potential to enhance growth particularly in agriculture, healthcare, and energy sectors. The study highlighted AI's capacity to address critical issues such as hunger, improve medical diagnostics, monitor public health, control disease outbreaks, and advance energy generation, distribution, and storage through innovative technological applications.

3. Methodology and Theory

This research employs secondary data analysis, involving the examination and interpretation of data previously collected by other sources. It also encompasses a review of existing scholarly literature and official reports from multilateral organizations concerning digitalization and artificial intelligence development. The data utilized in this study were obtained from archives, databases, and repositories, with pertinent conclusions derived from these sources. The primary theoretical framework is grounded in economic growth theory, which emphasizes the significant role that emerging technologies play in influencing the economies of developing nations (Asma et al., 2024). Critical factors include enhanced communication facilitated by improved technological infrastructure and the expanded reach to previously excluded populations living in poverty. Conversely, artificial intelligence may serve as a substitute for traditional factors of production and stimulate the emergence of novel ideas (see Comunale & Manera, 2024). This indicates that AI has the potential to induce sustained modifications in growth trajectories. From a theoretical standpoint, AI could promote economic growth by augmenting research and innovation activities (Korinek, 2023b). Empirical evidence supporting this proposition, as demonstrated by Brynjolfsson et al. (2023), suggests that AI could increase overall productivity by approximately 33 percent over a span of twenty years of integration into production processes.

4. Digitalization Penetration among Resource-Endowed African Countries

Digitalization has adopted a disruptive approach that requires significant transformation in the functioning of economies. Consequently, developmental policies in African countries must leverage the advantages of digitalization to enhance productivity, competitiveness, and efficiency across both resource-based and non-resource sectors. This shift holds the potential to facilitate the convergence of African economies with those of developed nations, given that many African countries are in the process of evolving along diverse developmental trajectories (Bhorat et al., 2023; IMF, 2024). An overview of digital adoption in Africa indicates that the continent still trails behind the rest of the world in terms of digitalization, although the digital divide is gradually diminishing (IMF, 2024). Data from African countries suggest that those with higher per capita income levels and access to coastlines tend to exhibit higher rates of digital penetration compared to landlocked nations. Furthermore, the COVID-19 pandemic has expedited digital adoption across Africa, as numerous countries implemented digital solutions to mitigate the impacts of lockdowns and movement restrictions.

Digitalization has generally been recognized as a catalyst for enhancing efficiency within the financial sector in countries such as Kenya, Mozambique, and Uganda, primarily through innovative developments in financial technology (fintech), which have led to the creation of new services and applications (see Jack et al., 2013; Ky et al., 2018; Okello et al., 2018). However, the development and implementation of digitalization across other sectors remain limited (IMF, 2024). Additionally, the widespread adoption of mobile money applications has been shown to facilitate financial transactions, thereby contributing to greater financial inclusion (Jack et al., 2013; Ky et al., 2018; Okello et al., 2018).

According to the African Union (AU, 2020), embracing digital technology is essential for advancing the continent's development agenda. African nations are prepared to undertake a comprehensive digital transformation strategy aimed at fostering a unified, coordinated approach to harness the opportunities presented by the fourth industrial revolution. Consequently, Africa's digitalization efforts are expected to build upon existing initiatives and frameworks, such as the Policy and Regulatory Initiative for Digital Africa (PRIDA), the Programme for Infrastructure Development in Africa (PIDA), the African Continental Free Trade Area (AfCFTA), the African Union Financial Institutions (AUFIs), the Single African Air Transport Market (SAATM), and the Free Movement of Persons (FMP). These efforts are intended to support the creation of a Digital Single Market (DSM) across the continent, aligning with broader economic integration goals and the strategic priorities of the African Union.

Despite the lucrative and meaning agenda of the AU which views digitalization mainly from the holistic perspective, sufficient attention has not been given to individual and specific efforts of African countries at embracing digital technology to promote growth and development of their respective countries. Since one of the specific objectives of this study is to appraise digitalization penetration among some specific resource-endowed African countries. This is with the view that development can only be achieved in Africa through robust digital technology penetration in priority sectors to enhance efficiency, competitiveness and profitability in the global market.

The efforts to promote digital penetration in resource-rich African nations, particularly South Africa, have been notable. South Africa has achieved considerable advancement in adopting digital technologies and has recognized digital transformation as a critical strategy for fostering economic growth and alleviating poverty (Harrison-Harvey et al., 2024). Compared to other nations within the continent, South Africa's progress is significant. Empirical evidence indicates that the country has developed policies aimed at leveraging the advantages of the digital economy across various sectors, including agriculture, mining, manufacturing, and transportation, while simultaneously safeguarding less digitized industries that continue to operate under traditional industrial paradigms (Abrahams et al., 2022; Harrison-Harvey et al., 2024). These sectors have undergone transformation through digitalization, altering their conventional value and supply chains and fostering new economic activities driven by the interaction between humans and technology (Mistra, 2024).

The telecommunications industry contributes approximately 5 percent to South Africa's gross domestic product (GDP), generates around 30,000 employment opportunities, and overall digitalization-related economic activities constitute about 15 percent of the national GDP (see Harrison-Harvey et al., 2024). Nonetheless, the advancement of digitalization has faced significant challenges, primarily related to the high costs associated with infrastructure and financing, volatile operational environments, and disruptions caused by government policies and institutional interference (Manda & Backhouse, 2018; Harrison-Harvey et al., 2024).

Nigeria has experienced substantial growth in digital adoption as technological advancement and digitalization have progressed within the country, particularly in sectors such as financial technology, e-commerce, and business enterprises (Olurinola et al., 2021; Samuel-Ogbu, 2022). In 2022, the Information and Communication Technology (ICT)

sector accounted for 18.44 percent of Nigeria's total gross domestic product (GDP), significantly surpassing the oil sector's contribution of only 6.33 percent, thereby highlighting the sector's critical role and economic importance for Nigeria (Ujah-Ogbuagu, 2023). The strength of the fintech industry has facilitated the rise of prominent firms such as Flutterwave, Paystack, and PiggyVest, alongside the development of digitally proficient commercial banks, which collectively have advanced financial automation and improved the efficiency of financial service delivery. Nonetheless, a considerable portion of households remain without access to broadband connectivity, and numerous enterprises are unable to fully leverage the opportunities presented by the expanding digital economy (World Bank, 2019; Ujah-Ogbuagu, 2023). Currently, Nigeria exhibits limited integration of digital technologies within sectors such as governance, healthcare, agriculture, and transportation.

In Algeria, initiatives were undertaken to adopt digital technology through the development and implementation of a strategic plan aimed at expanding digitalization, known as "e-Algeria 2013"; however, the targeted objectives were not achieved within the designated timeframe. The COVID-19 pandemic, nevertheless, acted as a catalyst, significantly accelerating digital adoption across various sectors of the Algerian economy, particularly in banking, commerce, healthcare, and education (Belhadi et al., 2024; Kafia et al., 2024; Sidi-Mammar & Si-Amer, 2025). Empirical research from Algeria presents mixed findings regarding digital penetration. While Nouri (2024) argued that digital technology fosters economic growth in Algeria, Sabiha and Oualid (2022) observed limited progress in digitalization, noting notable advancements only in health, industry, and service sectors. Overall, the integration of digital technologies into governance, manufacturing, and public services remains minimal in Algeria.

In contrast, Angola's ICT white paper for the period from 2019 to 2022 laid the groundwork for promoting and implementing digital technologies within the country's financial sector, with ongoing efforts to ensure that the young Angolan population gains access to these technologies. Similar to other African nations, the COVID-19 pandemic intensified the adoption of digital tools, especially within the educational sector (World Bank, 2023). Since then, continuous initiatives have been undertaken to enhance ICT infrastructure and internet connectivity across the country (Malomalo, 2024).

The Libyan government, through its Ministry of Communications and Informatics, formulated an e-government strategy designed to modernize public service delivery. This initiative, commonly known as "e-Libya," aims to position information and communication technology (ICT) at the core of all government operations to improve overall service efficiency within the country (Wynn et al., 2021). However, due to Libya's ongoing political instability, the project was put on hold in 2015. Efforts to revive the initiative have resumed since 2017, with the government renegotiating agreements with PricewaterhouseCoopers to develop a comprehensive e-government plan. Nonetheless, persistent instability continues to significantly hinder progress (Wynn et al., 2021). Libya's case is notably distinct because of its challenging political environment, which complicates the implementation of such digital transformation initiatives.

In contrast, Egypt has consistently recognized ICT as a critical driver of national development (Kamel, 2021). Specifically, the Ministry of Communication and Information Technology (2019) indicated that the ICT Sustainable Development Strategy 2030 was adopted primarily to encourage the adoption of digital technologies as catalysts for economic growth and employment generation. As a result, ICT has become one of the leading sectors contributing to Egypt's gross domestic product, accounting for approximately 4 percent in 2019 and increasing to about 5 percent in 2023 (World Bank, 2020c; International Trade Administration, 2024a). Furthermore, the COVID-19 pandemic has accelerated the adoption of digital technologies across various sectors, including manufacturing, agriculture, education, healthcare, and public services, as noted by the World Bank (2020c). Additionally, research by Ali (2024) highlights that globalization and digitalization are fostering digital inclusiveness in Egypt, particularly through the expansion of financial technology services.

In Ghana, substantial initiatives have been undertaken to transform the economy through the adoption of digital technologies. The primary objective of the government is to digitize economic activities within the informal sector by leveraging information and communication technologies (ICT) to maximize associated benefits. Consequently, the ICT sector experienced an approximate 19 percent growth between 2014 and 2020 (Ministry of Communication & Digitalization, 2022b). Current efforts are focused on digitalizing public services and broadening service delivery across the nation. Nonetheless, internet penetration and ICT utilization remain limited in certain critical regions due to inadequate or nonexistent service coverage, which hampers the country's digital inclusion agenda (Kpessa-Whyte & Dzisah, 2022).

As a result, the advancement of digitalization in Ghana has predominantly been driven by the service sector, with comparatively minimal contributions from the industrial and agricultural sectors (Yawson & Mahmoud, 2024). Empirical research indicates that digitalization holds significant potential to foster sustainable economic growth and

development in Ghana (Boakye et al., 2021). A study by Addison et al. (2024), examining the impact of agricultural digitalization on 525 rural farmers across northern, middle, and southern Ghana using probit and tobit estimation methods, found that although female farmers lag behind male farmers in the extent of digital technology adoption, factors such as higher educational levels, positive perceptions of digitalization, membership in cooperatives, larger household sizes with active members, and access to reliable electricity, internet, and mobile money services substantially enhance the utilization of digital technologies in agricultural practices.

Digitalization has increasingly garnered attention from the authorities of the Democratic Republic of Congo due to the growing contribution of the ICT sector to the national gross domestic product. For example, ICT accounted for approximately 3 percent of the GDP, despite the country remaining one of Africa's least developed and underfunded digital markets, with internet and mobile phone penetration rates of only 9 percent and 38.7 percent, respectively (World Bank, 2020a). In response, D. R. Congo has prioritized digitalization as a key element of its future development strategy, focusing on human capital enhancement, infrastructural expansion, and overall improvements in public service delivery (World Bank, 2022). Like other African nations, the COVID-19 pandemic has underscored the importance of adopting digital technologies to facilitate access to current information, improve public service provision, and enhance virtual education and remote working capabilities (World Bank, 2022). Presently, the government of D. R. Congo has established a major developmental goal of advancing digital transformation through the implementation of a five-year "digital economy strategy" titled "Vision Congo Digital 2025," aimed at fostering a resilient and dynamic digital economy (World Bank, 2022).

Similarly, digital transformation has been recognized as a crucial element for diversifying Gabon's economy and has been at the forefront of the country's economic and social development initiatives over the past decade. The nation's strategic digital transformation plan outlines an ambitious reform agenda aimed at establishing Gabon as a center of excellence in service provision and as a leader in the digital revolution by 2025 (World Bank, 2021a). Recently, the government has intensified its efforts to develop a modernized and diversified economy supported by high-quality public services. This economic development strategy seeks to cultivate a competitive, resilient, inclusive, and diversified economy, with digital advancement identified as a key driver of growth and societal change. However, investments in e-government initiatives have yielded limited results in terms of increasing adoption and enhancing service delivery effectiveness in the country (World Bank, 2021a).

Furthermore, the ICT sector and the adoption of digital technologies are considered fundamental to the economic transformation of Zimbabwe (African Development Bank, 2011). These technologies are leveraged to promote private enterprise, strengthen the public sector, and improve the livelihoods of all citizens (World Bank, 2021b). Nonetheless, ongoing political and economic crises have severely impeded the growth of the ICT sector, thereby restricting the potential benefits that digital technologies could offer. Empirical studies indicate that, despite an increasing trend of digital adoption in the agricultural sector particularly among smallholder farmers, digitalization has not translated into notable improvements in productivity within the country's agricultural industry (Hove et al., 2024).

In sum, studies conducted among selected African nations indicate that, despite the recognized importance of digital technology and the increasing digital penetration in resource-rich countries, significant efforts have been directed toward other secondary sectors such as manufacturing, financial technology, agriculture, informal markets, public services, healthcare, education, and general service delivery areas that do not align with their comparative advantages in the global economy. Nevertheless, South Africa has implemented initiatives to promote the adoption of digital technology within its mining sector, which is valued at over US$124 billion and exemplifies the country's resource endowment, viability of the mining sector and competitiveness in the global system (see Abrahams et al., 2022; Ashcroft, 2024; Harrison-Harvey et al., 2024; Okafor, 2024).

5. Sectoral Application of Artificial Intelligence on specific Endowment among Resource-Endowed African Countries

The adoption of artificial intelligence in Africa has experienced notable expansion, transforming a variety of sectors and industries (Musonda, 2024). On a global scale, AI is utilized across numerous domains including healthcare, finance, manufacturing, transportation, retail, and entertainment (Musonda, 2024). Financial institutions employ AI for purposes such as detecting fraud, assessing risks, executing algorithmic trading, and automating customer service functions. In manufacturing, AI contributes to improving production efficiency, ensuring quality control, enabling predictive maintenance, and optimizing supply chain operations. The transportation sector leverages AI for autonomous vehicle development, traffic management, route planning, and logistics coordination (Musonda, 2024).

Consequently, the deployment of AI within the realm of natural resource endowment has the potential to significantly enhance mineral extraction processes, thereby benefiting both global and local economies. Such advancements can promote sustainability, operational efficiency, and competitiveness at the individual country level, while also mitigating the negative environmental and social impacts associated with resource extraction. AI-driven applications offer a standardized platform that can expedite these processes (Corrigan & Ikonnikova, 2024). Evidence from resource-rich African nations indicates that South Africa continues to serve as the regional leader in attracting investments in emerging technologies like AI and cloud computing (Harrison-Harvey et al., 2024). These technological innovations are instrumental in lowering production costs and fostering productivity growth among South African enterprises.

South Africa remains a significant global producer of various mineral commodities, including gold, coal, platinum, palladium, manganese, titanium, and uranium. The mining sector accounts for approximately 8 percent of the country's gross domestic product and historically held a dominant economic position. This sector is predominantly labor-intensive with limited integration of artificial intelligence or digital technologies, unlike many industries that emerged following the mining boom in South Africa. As gold deposits are found at greater depths, technological innovations become increasingly necessary to access these resources, especially in cases where physical human intervention is impractical, highlighting the urgent need for digital transformation within mining operations. Benzane's (2019) pioneering research examines the adoption and application of digitization within South Africa's mining industry, indicating that digitalization primarily serves as a transformative force. It enhances various aspects such as digital capabilities, human resources, worker empowerment, organizational culture, customer experience, process automation, unified data management, and performance oversight in the sector.

Nigeria has recently unveiled a draft of its National Artificial Intelligence Strategy (NAIS) to harness the full potential of artificial intelligence in a manner that promotes ethical use for national development. This initiative has been developed in collaboration with U.S.-based technology companies that contributed expertise and input during the drafting process (International Trade Administration, 2024b). According to the NAIS, Nigeria faces a range of distinctive and compelling challenges and opportunities that AI can address, such as optimizing agricultural practices across diverse climates and enhancing the resilience of public health infrastructure. It is expected that establishing a domestically driven AI strategy with a clear framework for application will stimulate relevant innovations and contribute to rebalancing existing power dynamics. However, despite the recognized economic benefits of AI, the NAIS document does not explicitly address the role of AI and digitalization in advancing the downstream sector, which remains the backbone of Nigeria’s economy due to its significant contribution to revenue and foreign exchange earnings. The strategy primarily emphasizes overcoming obstacles related to developing and deploying local AI solutions, including enhancing public education, building a comprehensive data ecosystem, and encouraging public participation for shared economic prosperity.

Algeria's economy is heavily reliant on oil and gas, and fluctuations in global oil prices have adversely impacted its economic stability, leading to a slowdown in growth projections. Although digitalization and artificial intelligence (AI) have been recognized as key strategies for diversifying the Algerian economy and reducing dependence on hydrocarbon exports, current economic indicators suggest that Algeria's adoption of digital technologies remains relatively low despite governmental emphasis on integrating digitization, AI, and information and communication technologies (ICT) (Merwan & Faouzi, 2023). Nevertheless, pioneering research by El-Ouahed et al. (2005) demonstrated that Algeria is at the forefront in utilizing AI within the oil and gas sector, employing artificial neural networks (ANN) and fuzzy logic to create two-dimensional maps of fracture intensity and fracture networks for the natural fractured wells in the Hassi Messaoud oil field. This innovation has contributed to addressing challenges related to rig fracture issues, as well as difficulties in locating and orienting drilling operations.

In Angola, the deployment of AI remains minimal across both public and private sectors. Only a few institutions have begun to incorporate AI technologies to enhance their operations. For example, Angola Cables employed AI-based solutions to detect COVID-19 through tomographic image analysis, and the Angolan national police utilize an intelligent cluster detection system for investigative purposes (Ramalheira & Oliveira, 2021). These instances underscore the broader observation that AI application, particularly within critical sectors such as oil and mining, is largely absent in Angola.

Libya encounters multiple challenges that impede the advancement of artificial intelligence within the nation. These obstacles include insufficient infrastructure, limited access to data, inadequate technical capacity, and political instability (Bakeer, 2024). Such issues not only constrain the development of the agricultural sector but also hinder the integration of AI into industries such as oil and gas, mining, and other vital economic sectors (see Wynn et al., 2021). Consequently, Libya is unable to fully harness the potential benefits and opportunities that AI offers across various domains, particularly in sectors where it holds significant strategic importance.

In contrast, Egypt has recently embarked on digital transformation initiatives, especially within the healthcare sector, to enhance efficiency and reduce costs associated with medical services. This shift has been largely accelerated by the COVID-19 pandemic, which prompted a rapid adoption of AI and digital technologies. The country's efforts include increasing the use of telehealth applications and smart devices like smartphones and robotics. By 2030, Egypt aims to generate approximately 7.7 percent of its GDP from investments in AI development (Emara, 2021). However, the vision of establishing an AI-driven economy has been hindered by institutional and regulatory challenges, which exacerbate technical difficulties and restrict innovation, thereby impeding progress in key priority sectors.

Ghana possesses abundant natural resources, with over 80 percent of its export earnings derived from gold (49.8%), crude oil (21.5%), and cocoa (11.3%). The cocoa sector includes cocoa beans (7.4%), cocoa paste (2.3%), and butter (1.6%), along with other sectors accounting for 17.4% (see Economic Complexity Observatory, 2019). Nonetheless, the adoption of artificial intelligence (AI) remains in its early stages within the country, primarily initiated through the "Ghana 2033" initiative, which aims to develop an AI-driven society. This initiative envisions a transformed societal landscape where AI applications enhance the capabilities of individuals, government, businesses, and systems to foster inclusive social and economic development and improve overall quality of life (Ministry of Communication & Digitalization, 2022a).

The Republic of Congo is also a resource-rich nation; however, its economy is largely undiversified, with nearly 80 percent of exports originating from the oil sector (World Bank, 2022). The mining industry is predominantly characterized by artisanal and small-scale mining (ASM), which is associated with low levels of mechanization. Conversely, large-scale or industrial mining operations, such as the Kibali gold mine and the Kamoa-Kakula copper project, are increasingly adopting advanced mining technologies (International Institute of Sustainable Development, 2021). Consequently, the application of AI in Congo is primarily confined to large-scale mining activities, while small-scale, largely unregulated mining operations are largely overlooked in terms of technological integration.

Gabon possesses a wealth of natural resources, characterized by a diverse endowment of nonrenewable commodities. Predominant among these are petroleum, manganese, and to a lesser extent, uranium, iron ore, diamonds, and gold (World Bank, 2021a). However, the country's oil and mining sectors face significant challenges stemming from small-scale and illegal mining activities, which adversely impact the environment. Currently, there is a lack of strategic initiatives, such as the adoption of artificial intelligence and digital technologies, to address these issues within the sector.

Zimbabwe is a country endowed with substantial mineral resources, including extensive deposits of platinum, chrome, coal, and gold (Ashcroft, 2024; Okafor, 2024). The mining industry is increasingly recognized as a critical driver of economic growth, contributing approximately 80 percent to the nation's exports (Songola, 2024). The integration of artificial intelligence represents a novel development within Zimbabwe, particularly in the mining sector, where technological advancements are catalyzing a significant transformation. This shift promises improvements not only in operational efficiency but also in safety, productivity, and sustainability. Central to this evolution is the advancement of communication networks, which are already redefining mining operations across Zimbabwe (Muchowe, 2024). Additionally, AI is being leveraged for training purposes to further enhance productivity within the mining industry.

6. Conclusion and Policy Recommendation

The adoption of digital technology and artificial intelligence (AI) represents an emerging trend in Africa, offering significant potential to foster growth and development across the continent. Analyses of select African nations indicate that, despite the recognized importance of digital advancements particularly in sectors such as financial technology, agriculture, manufacturing, public services, health, and education there is a notable underutilization of digital resources in sectors aligned with their natural resource endowments, including oil, gas, and mineral extraction. South Africa, however, has prioritized the integration of digital technology within its mining industry. Conversely, AI adoption remains in its nascent stages across Africa, even among countries endowed with substantial natural resources, with nations like Ghana and Nigeria currently engaged in formulating AI policies. Some countries, such as Algeria, South Africa, and Zimbabwe, have demonstrated tangible applications of AI within their petroleum and mining sectors to enhance operational efficiency and productivity, driven by the competitive pressures of these industries. Accordingly, this study advocates that resource-rich African nations should undertake decisive measures to accelerate the adoption and implementation of digital technologies, moving beyond mere rhetoric. Such efforts should aim to leverage AI in sectors aligned with their resource endowments to improve efficiency, competitiveness, and productivity.

Compliance with ethical standards

Disclosure of Conflict of Interest

This study is a product of independent research and the outcome of the research is in line with the objective which the author intends to achieve and does not contradict any known conflict of interest.

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