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IS AFRICA JINXED? EXPLORING THE CHALLENGES OF TECHNOLOGY ACCESS AND ADOPTION IN AFRICA

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ABSTRACT: *Purpose-Africa, as a continent with an abundance of human and mineral resources, should have been among the superpowers of the world and have no business being poor. However, despite its richness, it is still considered a developing continent, while many of the countries in Africa are classified among developing nations, emerging economies, or least developed nations because they lag in all ramifications, technology inclusive. This paper critically examined the challenges faced in Africa concerning technology access and adoption specifically in agriculture, education, health and transport sectors. Methodology/Approach This is purely a conceptual paper. However, the Unified Theory of Acceptance and Use of Technology (UTAUT) was employed in this study. Findings: Many factors are responsible for Africa's downward trend in technology access and adoption. Infrastructure is a major challenge common to all the sectors considered though there are other challenges like computer literacy, lack of adequate training, low income, culture, and electricity. Interestingly, In Africa today, uptake poses a greater challenge than coverage. The disparity in adoption rates is most pronounced among elderly individuals, economically disadvantaged women, and households residing in rural areas. Additionally, informal enterprises and rural settings exhibit higher levels of this discrepancy. Research Limitations/Implications: Though the four sectors examined in this research are the primary sectors of the economy, sectors like banking, manufacturing, hospitality, real estate and others are open for research. This research, however, adds to the body of literature and should spur African governments and policymakers to ensure that Africa is moved forward with concise policies as many of the challenges highlighted have been in existence from time memorial.*

KEYWORDS: Africa, Sustainable Development, Technology Access, Technology Adoption.

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INTRODUCTION

Without a doubt, Africa is a continent rich in natural and people resources (Mogaji, 2021), and some academics and professionals even think that Africa is the continent of the future. Africa is the second most populous and largest continent in the world, behind Asia. It makes up 20% of Earth's land area and 6% of its total surface area, or roughly 30.3 million km2 (11.7 million square miles) when neighbouring islands are taken into account (Sayre, 1999). As of 2021 (UN, 2022), 1.4 billion people live there, making up around 18% of the global population. Africa has the youngest population of any continent (Harry, 2013); in 2012, the continent's median age was 19.7, compared to 30.4 globally (Janneh, 2012).

Africa is the least rich continent overall and the least wealthy per capita, trailing only Oceania, despite having an abundance of natural resources. In the larger global context, Africa is a significant economic market despite this low concentration of wealth due to recent economic progress and the continent's huge and youthful population.

If Africa would take its place as an important economic market of the 21st century, it should make technology a priority especially since the growth in technology transfer has greatly impacted various sectors of the economy across countries around the world (Osabuohien & Efobi, 2012; Mukoyama, 2003). For example, the rise in technology has brought about growth in cross-border trade, and investment (Osabuohien, 2010), and supported industrialization among emerging economies such as China, India, and Brazil which have successfully leapfrogged advanced technologies across sectors (You et. al., 2019). Research shows that digital technologies can enable economic transformation in Africa and create employment prospects for its populace. Digital technologies not only help everyone, including low-income and unskilled workers and entrepreneurs, to work and learn more effectively, but they also speed up the adoption and productivity of other supporting technologies.

Despite the availability of additional mobile internet options, Africa still lags behind other continents in terms of internet coverage. The issue of unequal access to digital resources persists in the most remote and poorest regions of the continent (Nduji et al., 2023).

In addressing the issues of technology access and adoption, we have critically examined four fundamental sectors of the African economy: agriculture, education, health and transportation.

There has been plenty of talk in the last few years on tech adoption across Sub-Saharan Africa, but that discourse however gapingly lacks a proper understanding of what impact access and use of technology have had on key sectors vital for growth and sustainability within the continent.

The drivers of technology adoption in agriculture, a backbone for several African economies include water and soil conservation technologies (Abdulai & Huffman 2013), the use of farming extension services such as agricultural extensions (Donkor et al. 2016), diffusion of innovative practices (Simtowe et al. 2016). These factors, which are central to increasing agricultural productivity and food security underscore the priority need for addressing systemic challenges in technology access and adoption within the agriculture sector.

Digital incorporation in education has the potential to change the ways knowledge is transferred and taught at all levels. But on the corollary challenges like; the superficial issue of digital infrastructure access and skill gap that creeps in when adopting new technology into an

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educational system are some Olubusola(2024); described as regulatory complexities. Overcoming these hurdles is a necessary step towards unlocking technology to reimagine and reshape education, from every corner of the African continent.

In health care, the use of Information and Communication Technologies (ICTs) holds great potential to increase access to services in underserved areas while improving quality therein. Nonetheless, significant challenges for up-scaling health technologies across Sub-Saharan Africa are presented by barriers including those related to infrastructure, policy frameworks and resource constraints (Bisi 2024). These are the issues that need to be overcome if healthcare is going to improve on a continent whose health outcomes lag behind those of most other parts of the world.

In addition, the transport sector is responsible for enabling rapid economic development and interconnectivity between African states. The problem of last-mile connectivity, which is an issue related to access to good internet services and transportation infrastructure, continues to hinder efficient transport systems (Mokeresete & Esiefarienrhe, 2021). The countries in Africa can use WiMAX/Digital transport and traffic solutions to increase connectedness, and accessibility of information, as well as drive development through efficient transport networks.

A continent with a high population should be able to feed itself and technology can transform farming activities and streamline production and value chains (Farayola et. al., 2020). Education is also the bedrock of any nation and on the African continent, the average age is 19. In India, the most populous country in the world, it is 28. It is 38 in both China and the US (NewYork Times, 2022). What this implies is that Africa needs to educate its young population and technology will play a pivotal role in achieving this (Mukuni 2019, Hoekstra 2013). In the health sector, Sub-Saharan Africa is home to 18% of the world's population (UN, 2024), but the region bears 27% of the global disease burden. Even worse, the same area with a high disease burden continues to lag in health information technology, which is essential to guaranteeing better patient care (Chaplin, et. al., 2015; Ajiboye, et. al., 2014; Cline, et. al., 2013) and as far as the movement of people and goods from one place to another is concerned, Africa lags in the infusion of technology into transport systems (Ajayi, et.al., 2021).

These challenges have made it very important to discuss new methods and interventions that can be done, together with some collaborative solutions on how Africa could provide easier not gated ways for a wide range of people to access leading technology. It is only if continents such as Africa think of a holistic and strategic approach to addressing these challenges that they can harness the full potential in achieving sustainability for themselves even as we rumble into an age where technology would be king.

The next section discusses the theoretical underpinning and does a critical examination of these sectors and the various challenges being faced in terms of technology access and adoption.

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THEORETICAL FRAMEWORK

Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive model that combines different views to create a synchronized framework for understanding an individual's intention to adopt and use IT. We chose to use the UTAUT model based on its ability to help analyse how technology adoption and access in Africa has faced challenges, as explored within this manuscript. The model of the UTAUT integrated several technology acceptance models and incorporates important factors including performance expectancy, effort expectancy, and social influence respectively facilitating conditions that affect individual intention to adopt or use any particular, new form of technology (Venkatesh et al., 2003). This holistic approach will allow related technology acceptance factors to be analyzed simultaneously and systematically, providing a framework for the characterisation of these technical adoption issues in the African context. Furthermore, Krismadinata et al. (2019) used the UTAUT model to determine the behavioural intention towards ICT adoption in elementary schools. Through a study of dependent and independent variables controlling performance expectancy, effort expectancy, social influence, and enabling environments researchers can evaluate human technology adoption based on the UTAUT model. Further, Ay (2023) utilized the UTAUT model as an assessment tool in their Online Exam System usability research. This is a demonstration of how far the UTAUT model can be stretched in assessing technology acceptance across many situations and settings, providing an invariant framework for analyzing user perceptions and behaviours concerning technology adoption. The UTAUT model can offer powerful insights into the factors that drive technology adoption in Africa, where digital access and tech-enablement challenges are particularly pervasive. The UTAUT model provides researchers with the necessary insights to identify barriers, facilitators and drivers of good technology adoption practices within Africa that can be leveraged for improving how Technology is made readily accessible and adopted across all sectors critical in ensuring real growth towards a better technological advancement transformation from one part of data generation era utilisation into modern digital product careers pathway. Incorporating the Unified Theory of Acceptance and Use of Technology (UTAUT) model in technological access/adoption research among African countries broadens our understanding towards the scope, and contextually exhaustive account of technology adoption challenges amongst regions. It gives a proper way to deal with these concerns systematically.

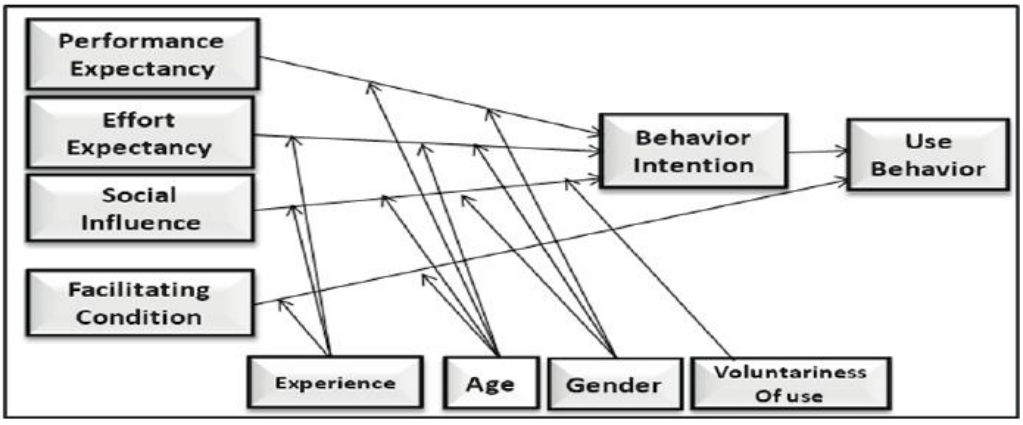

Fig 1: UTAUT
Source: *(Moghavvemi et al., 2013)*

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Technology Access and Adoption in the Agricultural Sector in Africa.

Agriculture is the single most important economic activity in Africa, providing employment, income, and food for the majority of the population (WEF, 2015; Otavio 2017). Since the majority of the world's fertile and underutilized land is located in sub-Saharan Africa (WEF, 2015), where more than 60% of the population lives in rural areas, agriculture accounts for around 24% of GDP and over half of all economic activity in the region. As a result, agriculture is fundamental to Africa's economy. The sector accounts for more than 32% of the gross domestic product of the continent.

The ITU (2016) states that commercial Agricultural Value Chains are a common approach for agriculture development and should adhere to national and international regulations where digital data of food products and related processing phases enhance marketing (Corallo et al., 2018). Agriculture plays a critical role in reducing poverty.

However, agriculture in Africa faces many challenges, such as low productivity, lack of subsidies, mechanisation, and supportive policies (Otavio, 2017). Agricultural productivity is still well below the standards observed in wealthy countries. More than 90% of agricultural activities rely solely on rainfall, without any assistance from artificial irrigation methods. The soil cultivation techniques currently employed are significantly lagging behind those implemented in Asia and the Americas. These approaches not only lack irrigation, but also fail to utilize fertilizers, herbicides, and high-yield seeds. Agriculture in Africa faces fundamental infrastructure challenges, including limited access to markets and financing, as well as significant barriers to the adoption and utilization of technology.

Challenges

Sub-Saharan Africa (SSA) exhibits the most significant disparity between the accessibility of digital infrastructure and the actual utilization by its population, compared to other regions worldwide. Across countries in Sub-Saharan Africa (SSA), the average percentage of a country's population with access to 3G mobile internet was 84%, while 63% had access to 4G mobile internet. However, only 22% of the population was using mobile internet services by the end of 2021 (GSMCA, 2021). The usage rates vary significantly among countries, with South Sudan having the lowest rate of 6% and South Africa having the highest rate of 53%. This highlights the diversity, especially during COVID-19 (Omale et al., 2023) in average usage and emphasizes the necessity for tailored policy adjustments in different countries. This indicates that the issue of adoption is currently more significant than the issue of availability, with the biggest disparity in adoption rates observed in rural areas and informal businesses. Additionally, older and economically disadvantaged women, as well as rural households, face considerable challenges in adopting these technologies (World Bank, 2023). The scarcity of technology and its sluggish implementation in the agricultural industry in Africa can be ascribed to a confluence of economic, political, and social factors (Hermanus & Osden, 2022). The primary barriers that lead to societal concerns affecting the utilization of digital technology by small-scale farmers are inadequate training in digital technology, limited awareness, poor infrastructure, and high expenses. The farmers' low adoption of digital technology and the lack of digital technology infrastructure in rural areas present substantial obstacles (Munyua, 2007). The limited expertise in digital technology among scholars and the inadequate power infrastructure for disseminating agricultural information to farmers are notable barriers (Musa et al., 2013).

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Small-scale farmers in Sudan's Gezira State face numerous challenges in embracing digital technologies. These factors encompass inadequate education, insufficient income, cultural reluctance to adopt new ideas, and a scarcity of materials available in local languages. Nmadu et al. (2013) discovered that language, poverty, and illiteracy pose substantial challenges for small-scale farmers in Nigeria in their use of digital technologies to acquire marketing information. A study conducted in Kenya found that small-scale farmers suffer from information shortages due to inadequate infrastructure, low literacy rates, lack of suitable information services, and a dearth of technical skills (Odini, 2014). Samii (2008) emphasized the difficulty that small-scale farmers encounter in accessing essential information and digital technological infrastructure, as discussed in a conference hosted by the International Fund for Agricultural Development (IFAD). The absence of access hinders their ability to establish connections with crucial participants in the agricultural value chain, including processors, traders, and consumers.

Technology Access and Adoption in the Education Sector in Africa.

Africa's future hinges on the role of children. According to Acapas (2016), Africa is projected to have a population of one billion children and adolescents under the age of 18 by the mid-21st century. According to ADEA (2016), this will constitute about 40 per cent of the global population of children and adolescents. Given the growing significance of the youth population, African nations must ensure that this demographic increase is advantageous rather than burdensome. They have an opportunity to enhance the prospects for young individuals and capitalize on their valuable human resources. Education empowers individuals to not only survive but also flourish, making it the most impactful investment in combating poverty and enhancing socioeconomic progress. Education serves as a barrier against the transfer of poverty from one generation to the next by offering increased chances for earning and positively influencing other socioeconomic factors. Education is correlated with peaceful communities, more civic involvement, and more robust democracies (Africa Union, 2018).

Efforts to achieve universal quality basic education are crucial for building resilience in populations and transforming a potential demographic burden into a valuable demographic dividend. This is achieved by fostering citizenship and creating a skilled and employable workforce that meets the specific needs of the labour market in terms of skills and competencies. The African Union acknowledges education as a crucial development priority, as stated in the Kigali Statement of Outcomes (ADB, 2021). This statement emphasizes the importance of providing fair and inclusive access to education for everyone, promoting education for sustainable development and global citizenship, and prioritizing the acquisition of literacy, skills, and competencies among youth and adults in sub-Saharan countries(Oyedele &Iember, 2021). These efforts align with the Education 2030 goals(Oladele et al., 2023). African nations have pledged to prioritize the comprehensive development of human resources by guaranteeing universal access to early childhood development and primary education, as well as making continuous investments in higher education, science, technology, research, and innovation. Throughout Africa, children and adolescents encounter obstacles that hinder their ability to access and utilize technology and digital resources. The gap is complex and has various dimensions. It encompasses disparities in internet access, mobile phone accessibility, proficiency in using mobile internet services, the capacity to develop technology and fundamental digital literacy skills (UNICEF, 2021). Presently, the percentage of households in Africa with internet connectivity stands at 34%, whereas approximately 89% of learners lack

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access to a computer in their homes (Pambe & Pilon, 2011). Just 53 per cent of pupils in Northern Africa and a mere 8 percent of students in sub-Saharan Africa possess computer access. According to the World Bank (2018), a mere 14 percent of students in sub-Saharan Africa have the privilege of internet connection in their own homes. Regarding internet and computer availability in schools, empirical data indicates that at least five African nations - Tanzania, Mauritania, Cabo Verde, Botswana, and Tunisia - provide pupils enrolled in lower secondary schools with computer access for educational purposes. Although many African countries are investing in technology to improve the quality of education and increase access, the additional funding may not always lead to the expected improvements in educational achievements (Piper et al., 2015; Porter et al., 2016; World Bank, 2012). The existing body of literature on the impact of technology on educational outcomes is replete with inconsistencies and contradictions, making it challenging to draw definitive cause-and-effect conclusions (UNESCO 2015). The quantifiable advantages and impacts mostly rely on the efficient implementation of technology, rather than the specific features and quantities of the technologies used (Porter et al. 2016; World Bank 2012). The sole focus on deployment is problematic, as May et al. (2014) contend that technology is better correctly characterized as a process rather than as a collection of things. Their impacts and utilization are heavily reliant on and interconnected with several other policy and program components (Piper et al. 2015). This phenomenon is seen in Sierra Leone. Sierra Leone's Ministry of Information and Communications created a national ICT policy in 2009 (Jackson 2015). However, according to UNESCO (2015), Sierra Leone is classified as one of several African countries that do not have clear planning frameworks and data collection mechanisms to encourage the use of technology in education. While technology is largely acknowledged as a useful resource for education in Africa, there seems to be a notable lack of understanding surrounding its use and effectiveness.

Challenges

The scarcity of energy has been a significant impediment to the integration of technology in Africa (World Bank 2015). According to UIS statistics, the proportion of primary schools in many African nations, such as Burkina Faso, the Democratic Republic of Congo, Malawi, and Tanzania, that possess electricity is less than 20% (UNESCO 2015:12). According to the data from Sierra Leone in 2012, only 3% of primary schools and 16% of lower secondary schools had electricity in educational facilities (Ibid). There is a shortage of electricity at the household level. Based on data from the International Energy Agency in 2014, it is projected that just 5% of homes in Sierra Leone have direct access to electricity. This percentage is further broken down into 11% in urban areas and 1% in rural regions. According to the UIS data from UNESCO in 2015, Botswana, Djibouti, and South Africa have electricity in 75% of their primary schools. However, Seychelles and Mauritius stand out as consistent outliers with 100% access to electricity in primary schools. The availability of electricity is a necessary condition for the functioning of any technology. However, the widespread lack of access to electricity in sub-Saharan Africa poses a major barrier to the utilization of technology, not only in the field of education but also in society at large.

One significant barrier to incorporating technology into education in Africa is the limited computer proficiency among teaching professionals in numerous educational environments. Integrating technology into education presents difficulties when considering the pedagogical aspect (World Bank 2012, World Bank 2016). The main focus is not just on the dissemination of technology, but also on finding the most efficient ways to help teachers create learning

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environments that include technology (World Bank 2012). Porter et al. (2016) emphasize that although there are several national and regional technology initiatives, such as the New Partnership for Africa's Development, Intel World Ahead, SchoolNET, One Laptop Per Child, and the Pan African Research Agenda, these initiatives generally do not effectively integrate technology into efficient instructional programs. A predominant approach has been to simply introduce technology and then passively await its impact, without fully acknowledging the pervasive influence of social, cultural, and political elements on technological developments. There is a widespread conviction in seeking technological solutions without sufficiently taking into account the impact of various individuals, organizations, and procedures on the implementation of technology in education. The absence of comprehension of this matter has substantial implications for technological policy.

The challenges posed by restricted energy availability and insufficient computer proficiency have led to the recognition of mobile phone technology platforms as a viable means for promoting education (World Bank 2012). The main reason for this is the extensive use of mobile phones, particularly devices and networks that support 3G, across Africa and other developing areas. This has led to a phenomenon known as leapfrogging when mobile phones have not only surpassed landline phones but also computers as the main method of accessing the internet. The references used are Collier and Venables (2012), Stork et al. (2013), Piper et al. (2015), and Porter et al. (2016). Mobile phones can somewhat alleviate electricity access challenges by their portability and capacity to store energy. Mobile phones offer consumers the ability to actively search for sites where they may access electricity, which makes them more adaptable in terms of obtaining power (Kemeny et al., 2014). Sierra Leone exemplifies the phenomenon of mobile phone usage. Despite the devastating civil war in the 1990s that inflicted significant harm to Sierra Leone's infrastructure, the country has managed to attain impressive levels of mobile phone ownership (over 50%) and network coverage (over 80%) (Sam 2015:3). The rates of ownership and usage are anticipated to increase further as a result of the accessibility of budget Chinese phone brands that offer internet connectivity, as well as the relatively inexpensive prepaid and postpaid data plans. The aforementioned characteristics are facilitating a more extensive acceptance and utilization of cell phones (Sam 2015).

Despite the widespread usage of mobile phones, there is a lack of research investigating the impact of these devices on education programs and outcomes (Piper et al., 2015; Porter et al., 2016). According to UNESCO (2012), most mobile learning programs are limited in scope and conducted on a small scale, typically remaining experimental and failing to grow or scale up. This could be attributed to the rapid pace of technological advancement. Porter et al. (2016) undertook a mixed-method study project in Ghana, Malawi, and South Africa, where they observed that mobile phones played a commonplace role in boosting education. The range of activities included helping classmates with their assignments and performing research on significant subjects, as well as validating test scores. This suggests that there is a possibility to improve the degree of integration and use. Sam's recent research in 2015 and 2017 has emphasized the beneficial impacts of the extensive utilization of mobile phones. These consequences encompass the empowerment of marginalized adolescents to assume agency over their lives and the cultivation of a sense of interconnectedness. Moreover, cell phones offer prospects for family reunions among individuals who were separated during the civil conflict. Sey and Ortoleva (2014) contend that focusing solely on assessing educational outcomes may lead to an underestimation of the potential worth and widespread appeal of mobile phones for activities such as social networking and gaming. These activities can foster

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the growth of social capital and digital proficiency in developing countries (Sey 2011). Mooketsi and Chigona (2014) share a comparable perspective in their research on the application of technology in disadvantaged schools in Cape Town, South Africa. However, there is also significant evidence suggesting negative outcomes, such as the increasing popularity of online gaming (Sam 2015), and suggestions that mobile phones enable student bullying and sexual harassment (Porter et al. 2016). Porter et al. (2016), Anyanwu (2016), and UNESCO (2012) have also noted disparities in mobile phone access between genders. These disparities can be attributed to unequal income distribution, limited social and cultural standards, and high illiteracy rates among women. While mobile phones can serve as a valuable educational tool, it is crucial to take into account the social, cultural, and political contexts in which they are utilized (Sam 2017). Considering the complex impacts of these aspects, it is clear that there is a need to enhance the psychological and technical readiness of both educators and learners (Piper et al., 2015). The incorporation of mobile phone technology into education in Africa, whether deliberate or not, will happen through different informal pathways. Therefore, policymakers are responsible for generating advantageous outcomes from this revolutionary technology.

Technology Access and Adoption in the Health Sector in Africa.

From 2000 onwards, Africa has made notable progress in improving health indices across all age groups (MDG Monitor, 2016). According to the World Health Organization (WHO), the region successfully reduced the mortality rates of malaria, HIV-1, and diarrhoea by 66%, 57%, and 52% respectively. Furthermore, the region successfully obtained substantial declines in death rates among children below the age of 5. Concurrently, Africa observed a significant increase of 3 years in its total average healthy life expectancy, surpassing all other global regions. The discrepancy in healthy life expectancies between African countries with the highest and lowest rates reduced from 27.5 to 22.0 years, according to the World Health Organization in 2024.

Nevertheless, the health situation in Africa remains complex. The area encounters remarkably elevated levels of avoidable neonatal and maternal mortality, along with fatalities resulting from infectious diseases, antimicrobial-resistant infections, and malnutrition. The recent economic advancements have resulted in lifestyle modifications, including unanticipated urbanization, elevated alcohol intake, and increased tobacco smoking. Furthermore, there is currently a widespread outbreak of non-communicable diseases, accounting for about 37% of all fatalities across the continent.

The health security of Africa, both currently and in the future, will depend on various variables. These considerations include the need to improve the capacity for specialized healthcare and research to address the aforementioned difficulties (Ndembi, 2023), as well as the requirement to reduce reliance on the importation of life-saving diagnoses, therapies, and medical technologies.

However, despite the health challenges faced in Africa, studies have shown that several African countries have adopted and implemented a wide range of e-health technologies and applications in healthcare institutions (Blaya, et.al., 2010). The study conducted by (Gustave, et.al. 2017) investigated the impact of information and communication technology (ICT) tools on the provision of healthcare in sub-Saharan Africa. The findings illustrate the considerable potential of these technologies in improving the efficiency and effectiveness of health care in

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hospitals. The results demonstrated a significant enhancement in clinical services, including patient identification, structured reporting, and financial management, as a result of using e-health tools in a cohort of 19 African healthcare institutions. Furthermore, the survey indicated that the mean waiting time decreased in 15 out of the 19 health centres. In addition, the introduction of real-time financial management indicators allowed hospitals to quickly identify fraudulent practices and incorrect billing procedures. A study conducted by Qureshiy (2016) found that ICT techniques such as GPS, data analysis, and cell phone records were used to track potential cases of the Ebola virus outbreak in Nigeria in 2014, to improve society. Likewise, social media and SMS were employed to increase public awareness and disseminate information about the dangerous nature of the disease.

Burney et. al. (2010) conducted a distinct study that examined the progress of e-health technology in underdeveloped countries. The study found that the utilization of e-health tools, such as telemedicine, m-health, barcode technology, radio frequency identification, clinical decision support systems, and picture archiving and communication systems, has a substantial beneficial effect on patient safety, dietary management, and document management. Collectively, these instruments augment the calibre of healthcare services offered to patients.

Challenges

In Africa, the health sector has a range of barriers preventing access and adoption of technology to enable better delivery of healthcare service outcomes as well as advance progress towards increased levels in health outcomes. Research and subsequent analyses have identified several key challenges, shedding light on the various complexities that fall under broad umbrella term barriers that need to be overcome if technology utilisation in healthcare will really materialise across the continent. The problem of the enormous human resources for health (HRH) gap, which has often been raised as a policy priority in many settings more recently by Oleribe et al. (2019). The lack of capacity for trained health professionals is a key constraint to using technology effectively for health technologies and only 45 % are equipped with the right skills to use new medical apparatus. Inadequate staffing and little domain expertise for using healthcare technologies lead to tech adoption problems in medical settings. In addition, Njoroge et al. (2017) highlight that though gains are beginning to be made through ICT-enabled health systems mechanisms, access and implementation disparities continue. While this is commendable, there are people in several African countries who have limited access to digital infrastructure such as internet connectivity and mobile devices. This poses severe challenges to the effective use of eHealth solutions by Africa although it may increase computer literacy on the continent. Furthermore, Sinde et al (2023) reveal several challenges to the adoption of AI in the health sector within Tanzania. The challenges are not new in Tanzania, and they do exist elsewhere across the African continent preventing AI technologies from being integrated into healthcare systems only reinforcing enormous potential for health improvements with innovative solutions driven by AI. Further, (Musa 2023) also believes that African health centres are often not sufficiently staffed and equipped with IT devices supporting fewer patients able to use healthcare services provided by these clinics. Other challenges include healthcare professionals' opposition, inadequate infrastructure, and limited technical abilities (Simon, et. al., 2007) while Sapirie (2000) argues that there is a significant disparity between the planning phase of adopting new technology and the successful and long-lasting application of that technology to achieve strategic or anticipated advantages. To incorporate new technology in the field of healthcare, healthcare workers and management must undertake a readiness assessment of health facilities. This assessment will provide guidelines that may effectively

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solve any potential difficulties that may arise following the introduction of the new technology. An evaluation of the system's successes and shortcomings should be undertaken at both an early stage of development and periodically after implementation (Kgasi & Kalema, 2014). Many African governments have not yet bridged the gap between planning to adopt e-health technology applications and successfully implementing them as a policy objective.

Successfully meeting the challenges to access and adoption implies a comprehensive approach, addressing the interplay between human resource limitations; digital infrastructure restrictions; training needs for skills development at all levels of healthcare personnel, and policy frameworks. When these barriers are overcome and tailored strategies to promote the adoption of technology are implemented, African nations can realize more technology solution benefits in advancing healthcare delivery, improving health outcomes and promoting the well-being of their populations.

Technology Access and Adoption in the Transportation Sector in Africa.

The transportation sector is essential for accomplishing the objectives of poverty reduction and sustainable development. The transport industry is intricately interconnected with and exerts impact on developments in other areas of the economy. In Africa, road transport is the primary form of motorized transportation, responsible for 80 per cent of the movement of products and 90 per cent of the movement of passengers on the continent (CFSSD, 2009). In 2001, the total length of roads in African countries was approximately 2.06 million km, which translates to a road density of 6.84 km per 100 sq. km. While the average ratio of roads to population for the entire continent is 26 km per 10,000 inhabitants, there is significant variation at the subregional level. Central Africa and Southern Africa exhibit the most extensive road networks, with 49.5 km and 56.3 km per 10,000 inhabitants, respectively. A majority of African nations encounter substantial expenses related to transportation (CFSSD, 2009). Africa's transportation and insurance expenses account for an average of 30% of the entire value of exports when accessing overseas markets. This percentage is higher than the 8.6% average for all developing countries, which is not advantageous. Landlocked countries experience the highest transport expenses among all countries on the continent, although most countries also confront this issue.

Recognizing the significance of integrating technology into transportation is crucial for addressing transportation challenges in Africa (Mogaji, 2020). ICT has been acknowledged as a vital enabler of sustainable development (Kayisire & Wei, 2016; Oyedele et al., 2024; Mohammed et al., 2024). ICT tools, including mobile phones, the Internet of Things (IoT), big data, radio frequency identification (RFID), and geographic information systems (GIS), have been utilized to advance sustainable development in several contexts (Kyem, 2012; Koria et al., 2014; Wang et al., 2015). The literature records the use of technical technologies to promote sustainable travel. Researchers have discovered that incorporating technology such as barcoding and decision support systems into haulier operations can enhance efficiency and enhance the overall experience for both service providers and users (Sternberg et al., 2014). Prior studies have demonstrated a correlation between competitiveness (Davies et al., 2007), safety (Harris et al., 2015; Wang et al., 2015), and well-being (Button et al., 2001) with the use of technological tools like GIS navigation and on-board computers (OBCs) in the transportation industry. However, there is little evidence to establish a correlation between technology and sustainable mobility in Africa, despite the importance of transportation as a key determinant of sustainable development as recognized by the United Nations. Moreover, transportation in Africa involves significant socio-economic costs (UN, 2016).

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Challenges

The transport sector in Africa confronts many constraints when it comes to the application of technology which greatly affects its efficiency and development. Barrier one is limited transportation infrastructure (roads, railways and ports), which undermines the efficient capitalising on high technologies (Kenny et al. 2022). Inadequate transportation systems prevent new solutions from being implemented and destabilize the integration of contemporary technology in existing infrastructure, eventually leading to low performance and ineffectiveness within its realms. In addition to these factors, the upfront capital costs of adopting new technologies are one significant roadblock in this industry. Similarly, critical cost factors that threaten the affordability of accepted technologies have been identified in studies such as solar photovoltaic systems in Nigeria (Ekung et al., 2020). Unfortunately, the transportation ecosystem - governments and private industry alike - is financially constrained to invest in new technological developments that are needed if they hope to advance into the present day. Moreover, in Africa, the transportation sector presents a major challenge due to skilled human resources and tech adoption expertise. This is because limited ICT skills may prevent individuals, communities and businesses from fully taking advantage of digital technologies including those related to transportation (Herrieth, 2023). A further limiting factor is the lack of trained personnel to operate and administer technical Solutions, slowing down their introduction - hardly gaining any benefit from new technology innovations targeting better organizational process efficiency. Besides, the segmented institutional framework in many African countries would restrict the extensive use of next-generation technologies across transportation. Decentralised systems, which foster autonomy and flexibility raise the challenge of implementing technology adoption initiatives across regions (Dzogbewu et al., 2022). Without centralized governance and coordination mechanisms, this heterogeneity in the rollout of technology leads to inefficiencies as well as disparities in access and adoption throughout the transportation sector. In a nutshell, collectively working on tackling infrastructure constraints and financing gaps as well as skills-inequities plus decentralization will help cope with tech access and embrace hurdles within Africa's transport. Creating holistic strategies to address these challenges will allow influencers to elevate the industry's technology capacity, and operational productivity and promote sustainable transportation across the continent.

Practical Implications

These instances of technology access and use across Africa have major repercussions for all key stakeholders—policymakers, schools, and nonprofits—to consider. Confronting these challenges demands a holistic approach which acknowledges the varying socio-economic and cultural landscapes of the African state. One of the practical implications is for educational technology solutions to be personalized to the goods and services required in different regions within Africa. As Tadesse et al. (2021) point out, the introduction of educational technology in East Africa should take into consideration that a “one size fits all” is counter-productive; answers rather must be adjusted to regional contexts and infrastructure capabilities. That means that the effectiveness of technology adoption can be improved and educational initiatives can meet the specific demands of the labour market. Secondly, the growth of mobile is a strong vector towards bridging the digital divide we know in Africa. Within an African context, Greunen and Veldsman (2018) further posit that by being mobile, the youth are more likely to respond to social change quickly; as they can harness technologies creatively to address economic and social challenges. This can be used to market digital literacy and the adoption of

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technology in rural and underprivileged areas. Efforts that centre around the idea of educating on mobile and sharing access to information can engage local populations while also providing a platform for new ideas, which at the root gives birth to economic growth. A second major implication is the critical need to overcome socio-economic barriers that inhibit technology take-up. Another study by Ngimwa and Wilson (2021) points out that low technology levels are not barriers in the way of the use of Open Educational Resources (OER), but it is due to socio-economic, cultural and institutional factors relevant to the adoption of OER. Therefore, stakeholders need to put priority on the policies which will improve infrastructure, financial support and a tech-friendly environment. This encompasses skills acquisition through digital literacy programs paired with ongoing collaborations between governments, schools and the private sector to provide access to technology. This will moreover create opportunities for technological access in Africa, and help to open up new innovative solutions (e.g. renewable energy projects). For instance, Akon Lighting Africa is a tool based on the use of solar energy to generate electricity in underserved -communities for access to technology (Ahmed et al., 2019). These projects are helping to fill energy holes, but they then start acting like an ecosystem in which technology can exist — providing education and economic opportunities. In sum, this is the type of real-world challenge presented by access and adoption that solutions can help address on the ground in Africa. Organizational stakeholders need to take a collaborative, context-oriented approach that is customized to meet the individual needs of different communities. Africa has the potential to forge ahead in the field of technology in education, health, agriculture and transportation to drive socio-economic development.

CONCLUSION

The analytical discussion of the hurdles to technology access and adoption-related challenges in Africa, within different sectors such as agriculture, health education, and transport, among others, ultimately identifies a complex environment that needs an integrated approach. The manuscript results provide insight into the complex dynamics affecting technology adoption in Africa's trajectory, highlighting targeted approaches that must be employed to adequately tackle these challenges. Evidence from the reviewed literature sheds light on the importance of human resource capacity, extension services, leadership support and innovation in influencing technology adoption for agriculture such as findings by Donkor et al. (2016) and Abdulai and Huffman (2013). Overall, these studies highlighted the importance of training extension officers and the adoption of sustainable agricultural practices in combination with improving productivity and technology uptake within the agriculture sector. Moreover, studies like Balogun (2018), Bisi (2024),and Mokeresete and Esiefarienrhe (2021) examined deploying digital practices within the education sector, healthcare facilities, and transport industries. These studies highlight how a lack of resources, regulatory hurdles and everything from connectivity to intestinal issues at the last mile makes it difficult for tech providers to break through in these arguably most important verticals. In summary, the manuscript makes a strong contribution to existing literature by providing district-level insights on issues shaping technology access and adoption in Africa. These include policy interventions, innovative strategies and capacity-building initiatives that can be leveraged to overcome the identified barriers; thereby enabling technology innovation for sustainable development and improved quality of life in Africa.

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