Intersecting Digital Governance and Sustainable Development Goals in Africa

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Received: 14 October 2024| Accepted: 31 January 2025| Published: 31 May 2025

Abstract

The advent of Information and Communication Technologies (ICTs) and the internet has revolutionalised the manner in which governments and citizens interact as well as service delivery models. Digital tools have the potential to promote sustainable economic transformation and development within the 21st Century by ensuring that governments attain cost efficiency and effectiveness gains. The successful attainment of Agenda 2030 has become a priority for all governments across the globe and Africa is no exception. There is acknowledgement that the Agenda 2030 can be driven by digitisation efforts. However, there is little scholarly evidence which indicates how digital tools can be incorporated in SDGs implementation in Africa. The study adopted extant secondary qualitative literature as the research method. Findings, conclusions and recommendations were drawn from documentary books, journal articles, working papers and government reports. This study focused on examining how ICTs can be incorporated in the SDGs' implementation trajectory, progress made and challenges being faced. The study findings established that despite progress made in adopting ICTs by several African countries, most of them have failed to fully embrace ICTs in driving the implementation of SDGs. African countries are facing underlying problems which include digital divide, lack of political will, lack of skills and limited funding, among others, which have been a hindrance towards their digitisation efforts. The study recommended that governments in Africa have to invest in regulatory and policy frameworks, source adequate funding for digital projects and educate the general populace on ICTs.

Keywords: Sustainable Development Goals, Information and Communication Technologies, Fourth Industrial Revolution, Digitalisation, Public Service Delivery

Introduction

In September 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development including the 17 Sustainable Development Goals (SDGs) (Sheriff, Debela, Turay, Kabia, & Sesay, 2020:30). The applicability and priority of individual SDGs, considering different national realities, vary across member states. In recognition of this variability, the formulation of national indicators, selection of targets, and development of priorities was and would continue to be the ultimate role of individual countries (Allen, Metternicht & Wiedmann, 2016). The post-2015 development framework is seen as a sign of international concerted effort and commitment, focused on advancing social inclusion, environmental protection and economic growth in a mutually reinforcing manner. This comprehensive agenda serves not only as an important policy instrument for international development cooperation but also as a national development mechanism of all United Nations member states from 2016 – 2030 (Chams & García-Blandón, 2019).

SDGs, call for several bold breakthroughs by the year 2030 especially in African countries, including the end of extreme poverty (SDG 1) and hunger (SDG 2), universal health coverage (SDG 3), universal secondary education (SDG 4), achieve gender equality (SDG5), ensure sustainable management of water and sanitation (SDG6), universal access to modern energy services (SDG 7), ensure economic growth (SDG8), ensure sustainable industry, innovation and infrastructure (SDG9), reduce inequality (SDG10), sustainable cities (SDG 11), ensure responsible consumption and production (SDG12), combatting climate change (SDG 13), and protecting marine (SDG 14), terrestrial ecosystems (SDG 15), ensure peaceful and inclusive societies (SDG16) and ensure global partnerships (SDG17) (United Nations, 2024). They are definitely ideal goals that requires a transformation of societies that is far deeper and faster than in the past.

SDGs, to be achieved, must leverage existing and widely deployed technologies, such as broadband, but also require new innovative services and improved reach of technological solutions. The broad application of ICT is a profound reason for optimism, since the rapid development of ICT-based services and systems offer the possibility for the needed deep transformation of the world economy and societies more broadly (Jeffrey, Sachs, Modi, Figueroa, Machado, Sanyal, Khatun, & Shah, 2017:2). ICTs world over have contributed to creating learning opportunities for women and various marginalised groups, reduced inequalities by extending healthcare to remote areas, and providing channels for more open and transparent dialogue and the co-creation of policies. ICTs have also helped to build disadvantaged communities' resilience to the effects of climate change through various local innovations and applications that improve logistics systems and market access, agricultural productivity, offer financial services like mobile money, and provide early disaster warning services (United Nations, 2021:6).

Many African countries have formulated and adopted explicit ICT policies. In 2000, fewer than 15 countries had policies for promoting science and technology. Now many more countries have ICT policy frameworks, including Botswana, Burundi, Cameroon, Algeria, Angola, Egypt, Ethiopia, The Gambia, Ghana, Kenya, Malawi, Mali, Seychelles, Sudan, Swaziland, South Africa, Tunisia, Mozambique, Namibia, Nigeria, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe (United Nations, 2021:6). However, the benefit of ICTs is not equitably distributed within and between countries and regions in Africa. There are still millions of people who have no access to ICTs and even basic services such as health treatments, clean water and sanitation, secure energy and means of communication. In some cases, the development, diffusion and deployment of communication technologies have increased social exclusion and widening the digital divide in African countries (Namubiru-Mwaura & Marincola, 2018:18).

It is against this bedrock that this study analysed the intersection of ICTs and SDGs in Africa. The objectives of the study are to analyse opportunities of intersecting ICTs and SDGs and also challenges facing African countries in adopting ICTs to achieve the SDGs. The study adopted extant secondary qualitative literature as the research method. The study was structured into five sections, and these included emerging technologies and SDGs, research methodology, research findings and analysis: intersecting ICTs and SDGs in Africa, challenges facing African countries in adopting ICTs and conclusions and recommendations.

Emerging Technologies and SDGs

The technology landscape is in a constant state of change with new innovations shaping the industry being introduced (ICT Authority, 2020:14). Rapid developments in the fields of

internet of things, big data, artificial intelligence (AI), augmented reality robotics, block chain technology, sensors and rapid prototyping technologies have noticeably transcended into all sectors of the economy (United Nations, 2021:4). Digitalisation is therefore transforming the way people are living and the way goods are produced and consumed (Energy and Resources Institute, 2019:1). These frontier technologies are being used to promote growth in all sectors such as education, agriculture and health among others, while those who lack access to ICTs risk being left further behind. Some emerging technologies are further discussed below.

Artificial Intelligence (AI)

AI is a set of technologies that enable a computer or computers to perform various functions which include the ability to understand, see and translate written and spoken language, analyse data and make recommendations (Wamba, Queiroz, Pappas & Sullivan, 2024). AI is used by businesses, governments, and other institutions to reduce costs, improve efficiency and extract deep learning insights with the help of complex data analysis (Shenkoya & Kim, 2023). While research on intersecting AI and SDGs is still nascent, emerging analysis shows that in addition to many other areas, AI could be effective in improving almost all SDGs (Huawei Technologies, 2019:20). Taking for instance, AI can make information more reliable, precision/genomic medicine, energy efficient houses, online education, renewable areas and remote sensing, among others (Singh, Kanaujia, Singh & Vinuesa, 2023).

To add on, AI may act as an enabler for supporting the provision of water, food and energy services to the population. It can also underpin low-carbon systems, for example, by supporting the creation of smart cities and circular economies that efficiently use their resources. For instance, AI can enable smart and low-carbon cities encompassing a range of interconnected technologies like electric vehicles and smart appliances that can enable demand response in the electricity sector with benefits across SDGs 7, 11, and 13 on climate action (Singh, et al, 2023). AI can also help to integrate variable renewables by enabling smart grids that partially match electrical demand to times when the sun is shining and the wind is blowing (Vinuesa, Azizpour, Leite, Balaam, Dignum, Domisch, Felländer, Langhans, Tegmark & Nerini. 2020:2).

Quantum Computing

Quantum computing is a multidisciplinary field comprising aspects of computer science, mathematics and physics that make use of quantum mechanics to solve complex problems faster than classical computers (Matinmikko-Blue, 2020:15). Quantum technologies leverage the unique principles of quantum mechanics, which include quantisation, interference, entanglement, uncertainty principle and decoherence, to produce useful devices and scientific advancements not possible with classical technologies. As a result, quantum technologies, in particular, offer specific merits that make communications networks unbreakable and secure and devices with unprecedented levels of accuracy, reliability, scalability, responsiveness and efficiency than classical emerging technologies (Mafu & Senekane, 2023:1).

Quantum computing can be used for agricultural fertilisation, financial modeling, drug metabolism, cybersecurity, route and traffic optimisation and manufacturing among others (Matinmikko-Blue, 2020:15). These capabilities can contribute towards SDGS such as addressing energy crisis, national security, climate change, agriculture, education, healthcare and economic growth challenges (Aljaafari, 2023). Unfortunately, these developments in these areas have not been evenly distributed between the Global North and the Global South, inadvertently creating a societal and economic gap between developed and developing nations. Closing this gap is critical in order to create a more inclusive and sustainable future for all, thus delivering key sustainable goals (Mafu and Senekane, 2023:1).

Fifth and Sixth Generation Wireless Technology

Five Generation (5G), denoting the fifth generation of mobile communication technology, signifies a paradigm shift in connectivity and communication. 5G is the fifth generation of wireless cellular technology offering high speeds, more consistent connections and improved capacity than previous networks (Matinmikko-Blue, 2020:22). At its core, 5G is engineered to deliver superior data transfer speeds, low latency, and support for an extensive array of connected devices. The architecture of 5G is characterised by a combination of cloud-based infrastructure, radio access technologies and software-defined networking. The 5G cellular system is designed to create an immensely scalable and flexible network connecting a myriad of devices and users across various industries (Odida, 2024:4). These solutions provide invaluable services in areas such as education, healthcare, and environmental protection, and help address many of society's challenges which are all SDGs (Huawei Technologies, 2019:20). As of the year 2023, the deployment of 5G has experienced substantial momentum, witnessing active implementation in numerous countries around the world including Africa. Leading the way are developed nations such as the United States, South Korea, China, and various European countries, where comprehensive 5G infrastructure is being established (Odida, 2024:7).

Sixth Generation (6G) is the wireless which is the successor to 5G cellular technology. 6G network will be able to use higher frequencies than 5G networks and provide substantially higher capacity and lower latency and may be available before 2030 (Odida, 2024). Building on the existing mapping between SDGs and ICT, future technologies, such as 6G, are not thoroughly captured in the linkages or indicators. 6G can be seen as an opportunity to make a positive impact and be the accelerator for the advancement of SDGs. The pursuing of SDGs is a social and societal effort and can direct public resources to, among other things, extending the network infrastructure required for 6G beyond urban centers and developed countries. Implementing the 6G technology has to be affordable especially for African countries. Another opportunity for African countries is to exploit the existing and evolving infrastructure which is already being build including fiber optic backhaul infrastructure (Matinmikko-Blue, 2020:22).

Nanotechnology

Nanotechnology is another technology with the potential to transform SDGs and address societal and economic challenges. It involves scientific techniques that manipulate small particles and/or very thin films to develop or exploit unique properties of materials. Like ICTs and biotechnology, nanotechnology enjoys wide application across sectors (Batool, Nabipour, Ramakrishna & Mozafari, 2022). It offers an enormous range of applications in various areas of SDGS such as health and medicine, agriculture and environmental and water management, among other areas. For instance, with the help of nano medicine early detection and prevention, improved diagnosis, proper treatment and follow-up of diseases is possible. Gene sequencing has become more efficient with the invention of nano devices like gold nano particles which when tagged with short segments of DNA can be used for detection of genetic sequence in a sample (Namubiru-Mwaura & Marincola, 2018:20).

The green revolution of the 20th century was driven by a blind use of chemical fertilisers and pesticides resulting in a loss of soil biodiversity and a rise in resistance against pathogens and pests (Batool, Nabipour, Ramakrishna & Mozafari, 2022). The new revolution will be precision agriculture, driven by nanotechnology. This revolution will see nanoparticles delivered to plants and advanced biosensors for precision farming. Nano-encapsulated conventional fertilisers, herbicides and pesticides will release nutrients and agrochemicals in a slow and sustained manner, resulting in precise dosage to the plants (Energy and Resources Institute,

2019:10). To add on, roughly 60 percent of applied fertilisers are lost to the environment, causing pollution and nano-fertilisers helps in the slow, sustained release of agrochemicals resulting in precise dosages, greater plant protection and treatment of diseases. Biosensors can detect pesticides in crops, leading to more-informed decisions (Energy and Resources Institute, 2019:11).

Research Methodology

Extant secondary qualitative literature was the research method used to gather information. This approach was aimed to comprehend the intersection of ICTs and SDGs in Africa. As a means of gathering specific and needed information, the analysis relied on secondary data. Findings, conclusions and recommendations were drawn from documentary search of books, journal articles and working papers.

Results and Discussion

Intersecting ICT and SDGs in Africa

No poverty (SDG1)

The attainment of SDG1 (no poverty) is, to a large extent, dependent on achieving the other 16 goals. Poverty is a manifestation of hunger, disease, social exclusion and inequalities, lack of access to water, sanitation and environmentally safe energy, vulnerability to climate change and its consequences, such as drought and floods, lack of access to healthcare, and exclusion from decision-making (Namubiru-Mwaura & Marincola, 2018:22). More than 60 percent of the population in sub-Saharan Africa lives in rural areas with high adult illiteracy, low access to formal healthcare, and low levels of maternal education. Most rural families, with limited resources, are unable to invest in their children's health and education (Ngila, Matheri & Mbohwa, 2024:2). This produces a generation of children with reduced physical and cognitive development, as well as limited education, reducing their chances of breaking the cycle (Henao, Hui & Shaw, 2017:52).

Poverty alleviation requires investment in ICTs to confront and address its manifestations. ICTs are enablers of human development, and they make it possible for individuals and communities to access economic and social amenities (Namubiru-Mwaura & Marincola, 2018:22). ICTs have contributed to poverty alleviation by making the needs of the vulnerable visible with the use of real-time data and analytics (United Nations, 2021:12). Digital financial services allow many to participate in the digital economy for the first time and access to financial services has proven to be a pivotal step in helping people lead out of poverty (Matinmikko-Blue, 2020:18). In Kenya, for example, the mobile banking service that allow users of M-PESA to store and transfer money through their mobile phones, has revolutionised lives of many people where more than 95 percent of the population has access to financial services through mobile banking. This technology has alleviated poverty among the population not just in Kenya but more than 10 countries where M-PESA services are being used. However, poor individuals living in rural areas are disproportionally without access to ICTs and unable to take advantage of these benefits (Ngila, et al, 2024:2).

Zero hunger and improved agriculture (SDG2)

In spite of its huge potential in agriculture, Africa has some of the highest regional importers of food in the world. West Africa, for example, imports up to 40% of its rice, with Thailand as the main supplier. This means that, across the continent, 30% of all cereals consumed are imported (Henao, et al, 2017:33). Statistics show that continued food insecurity directly affects

239 million Africans, with 30% to 40% of children under the age of 5 years continuing to suffer from chronic under-nutrition at a critical stage for both survival and cognitive and physical development (African Union Commission, 2024:22). This shows that food insecurity has already become an increasingly relevant and pressing concern. ICT in this case can enhance agricultural productivity in Africa through technological innovation, ensuring food security and promoting sustainable practices (Ngila, et al, 2024:2). ICT helps farmers improve crop yields and business productivity through better access to market information, weather forecasts, training programmes, and other tailored online content (Matinmikko Blue, Yrjölä, Ahokangas, Ojutkangas & Rossi, 2021:1345). Taking a look at Kenya for example, Farmers Helpful Network (FHN) provides farmers with information on crop rotation, artificial insemination, and crop insurance. This enables farmers to make informed decisions and to improve their agricultural production and profitability (Namubiru-Mwaura & Marincola, 2018:32).

Advanced technologies, like AI and drone, have been used to solve various problems in agriculture to address food security. Innovations in weather prediction, automated irrigation, soil monitoring, crop monitoring, new farming techniques with smart greenhouses, harvesting, techniques using robotics for picking strawberries, pests, diseases, weeds prediction and biotechnology, among others, enhance agricultural productivity. Countries such as South Africa, Rwanda, Kenya and Zambia have benefitted from these technologies (Ngila, et al, 2024:2). However, most African countries have not adopted national policies and strategies for promoting the development and application of biotechnology. Many countries have adopted biosafety regulations, mainly in response to the United Nations Cartagena Protocol on Biosafety, to regulate the development and application of modern biotechnology and these include Ghana, Kenya, Malawi, Tanzania, Uganda, Mali, Mozambique, Namibia, Nigeria, Senegal, South Africa, Burkina Faso, Cameroon, Egypt, Ethiopia, Sudan, Swaziland, Zambia and Zimbabwe (Namubiru-Mwaura & Marincola, 2018:32).

Good health and wellbeing (SDG3)

Chronic and catastrophic disease remains one of the main factors that push households from poverty into deprivation. The African region lags behind other regions of the world on practically all indicators of health, with communicable diseases accounting for approximately two-thirds of the disease burden (Henao, et al, 2017:23). Every year millions of Africans die of communicable and non-communicable diseases that are preventable and treatable as a result of inadequate resourcing to scale proven interventions, poor human resources management, weak and fragmented health systems, limited access to health services and technologies especially in rural areas and extreme poverty (African Union Commission, 2024:22). Attaining SDG3 involves eradicating communicable and non-communicable diseases and achieving nutritional security (Ngila, et al, 2024). ICTs in this regard is pivotal to ensure good health and well-being. Technology is driving the global search for good health and well-being. It is informing many public health measures by enhancing insights into the causes of diseases and transmission of vectors (Namubiru-Mwaura & Marincola, 2018:22).

ICTs enable communication with medical practitioners, provide access to health programmes, provide digital identity service to access healthcare, monitor well-being through mobile, provides big data for epidemics and improve water quality through internet of things (Matinmikko Blue, et al, 2021:1345). For instance, the Zidi software invented in Kenya is capable of making appointments for patients, it is able to do inventories, write medical reports for patients and the system is able to do work related to the human resources management. The software is being used across Kenya, and it has been installed in 60 private health facilities and 28 public health facilities including three public hospitals in Nairobi (Mathane & Gumbo,

2022:4973). It is however important to note that technological innovations in the health sector around the world exists such as uterotonics to prevent postpartum haemorrhage, oral rehydration solution to treat diarrhea, and new nucleic acid amplification tests for rapid diagnosis of Tuberculosis. Nevertheless, these and other health innovations are not easily accessible in many low-income countries especially in Africa where they are needed most. These countries have weak innovation systems to procure, adapt and diffuse existing technologies (Namubiru-Mwaura & Marincola, 2018:23).

Inclusive and quality education (SDG4)

Educational challenges in African states affect the most disadvantaged and difficult to reach populations who also face poverty, cultural barriers, conflict and other humanitarian emergencies. The most impacted segments of the population are females, and 12 million girls as compared to 7 million boys in sub-Saharan Africa who are never expected to attend school (Henao, et al, 2017:23). ICTs has however proved to bridge the educational gaps in African countries for the realisation of SDG4. It started with the use of conventional media such as radio and television to increase access to education, which continues to be used today together with newer digital technologies (United Nations, 2021:16). Mobile devices allow students to access learning assets anytime and anywhere (Yrjölä, Ahokangas, & Matinmikko-Blue, 2020). They have been used to bridge learning divides, enhance the quality and relevance of learning, and strengthen inclusion to provide educational access to those who, for reasons of geographic location, gender, conflict, poverty, physical disability, occupational commitments or cultural restrictions, are unable to go to school (United Nations, 2021:16).

Online teaching and learning have revolutionised education globally and particularly the African continent which has ripped huge benefits in terms of access to education (United Nations, 2021:11). For example, the Africa Centre of Excellence on Technology Enhanced Learning (ACETEL) was established in February 2019 and is located at the headquarters of the National Open University of Nigeria in Nigeria. The centre is one of the 54 centres supported by the World Bank. The Centre focuses on the development of human capacity and research in digital solutions that will lead to the utilisation of technology for education and its deployment to other sectors (Ngila, et al, 2024:2). However, online teaching and learning in Africa during the COVID-19 crisis exposed inequalities and the complex interplay of the different types of inequalities throughout society that exacerbate each other. For instance, children in households without access to computers and the Internet missed out on education during lockdowns (United Nations, 2021:11).

Gender equality (SDG5)

Women and girls are the most secluded population in African states when it comes to access to education, health and economic activities, among others. Women and girls represent a disproportionally high share of the world's offline population (Ngila, et al, 2024). In 2019, the worldwide Internet penetration rate stood at 58.3 percent for men, compared to 48.4 percent for women. This figure translates to 400 million fewer women using the Internet when compared to men. Women are also 8 percent less likely to own a mobile phone and 20 percent less likely to own a smartphone (United Nations, 2021:13). ICTs offer vast potential to enhance women's empowerment and advance SDG5 on gender equality. From improving women's health outcomes and extending access to educational tools, to boosting their participation in economic activities such as e-commerce, ICTs can connect women to the global community and bypass some of the sociocultural and mobility barriers they face offline (Matinmikko Blue, et al, 2021:1345; United Nations, 2021:13).

African countries have made strides to ensure gender equality through ICTs. The Smart Rwanda 2020 Master Plan highlights the empowerment of women and youth in ICT as one of its pillars. Through the plan, the government of Rwanda committed to facilitate women and girls in ICT capacity building and facilitate projects related to increasing women and girls in ICT related business. This strategy sort to address gender digital divide which limits women's ability to participate fully towards building an equitable knowledge-based society (ICT Hub Strategy, 2024:8). Closing this gender digital divide is therefore a national key objective and one that will empower the Rwandan women further and ensure their full participation based on equality in all spheres of society. However, even when women are included, cyber violence and online hate speech against women limit the continuous use of these technologies, while lack of legal frameworks fails to capture the prevalence of violence and the social and psychological harm it produces (United Nations, 2021:14).

Clean water and sanitation (SDG6)

Water scarcity has always been a challenge in many African countries, and it has been exacerbated by climate change and El Nino, which has recently caused dry spells in Zimbabwe, Malawi, Mozambique, South Africa, Zambia and Madagascar in 2022 and 2023. Water scarcity has negative a effect on sanitation which calls for prompt action to realise SDG6 (Ngila, et al, 2024). Hence, the water industry, and in particular water utilities, needs to adapt to meet the emerging demands of a dynamic, highly deregulated and competitive environment within the context of a changing climate. In such an environment, water utilities need to continue to deliver essential services including safe and secure drinking water, storm-water management and wastewater management (Energy and Resources Institute, 2019:14). Addressing these challenges requires a transformation to optimise its processes and operational efficiency. These challenges necessitate a paradigm shift to the next generation of water systems beyond traditional water and sewerage infrastructure that is making use of ICTs.

ICT enables intelligent water management, facilitating the measurement and monitoring of water supplies as well as necessary interventions. It enables practitioners at the local level to ensure the equitable and sustainable extension of water, sanitation and hygiene services (Yrjölä, et al, 2020). Water quality sensor technologies, remote sensing and assessment technologies, bioremediation, and other technologies offer enormous potential for achieving SDG6. Promoting wider access to and building local capacities to use the technologies and increasing investment in ICT are issues that national and international policies must focus on (Namubiru-Mwaura & Marincola, 2018:24). In Africa for example, City of Cape Town make use of sensors in water utilities. Data extracted from smart water meters was used during the 2017 water crisis in Cape Town to analyse how households responded to the water crisis and residents are updated in real-time with regards to water disruptions and how best to conserve water (Belaid & Arora, 2024).

Affordable and clean energy (SDG7)

The provision of water in Africa, within the broader category of energy provision, infrastructure and access, remains an acute challenge. Despite being home to approximately 15 percent of the world population, Africa only accounts for 4 percent of the global energy demand. More than 600 million people do not have access to electricity and over 700 million people rely on biomass for cooking, leading to pronounced deforestation and significant health challenges (Henao, et al, 2017:46). Digital technologies offer solutions to the challenges of power outages by integrating renewable energy sources into small and large power grids in order to supplement electricity to the power grid. ICT solutions also offer the potentials to monitor and efficiently manage the generation, delivery and consumption of electricity to meet the varying

electricity demands of end-users. Smart grids also provide the flexibility necessary to integrated renewable energies such as wind and solar into electricity networks on a large scale (Energy and Resources Institute, 2019:42).

Smart meters and online portals for office and home to see meter data and tools for maximising efficiency of energy use and enhance tailored solutions big data analytics for modelling and scenario planning 3D printing, robotics, and other ICT-enabled manufacturing developments helps ensure more efficient energy storage by informing when and how energy should be stored efficiency (Huawei Technologies, 2019:22). In Africa, cities like Johannesburg and Cape Town managed to implement smart meters for its electricity distribution and this has managed to increase its distribution management as well as revenue (Backhouse, Karuri-Sebina, & Guya, 2020:7). However, the development and implementation of climate change and energy technology across African states is proving to be difficulty due to insufficient funds, technology and infrastructure leading to continued loadshedding especially in South Africa and Zimbabwe which also rely on thermal energy from coal (Belaid &Arora, 2024).

Sustainable cities and communities (SDG11)

The pressure of urbanisation, coupled with lingering economic instability and global climate change, has created various new challenges for African cities, such as traffic congestion, crime, economic stagnation, population segregation and air pollution (Organisation for Economic Co-operation and Development (OECD) 2019). To deal with these urban challenges, the notion of the smart city has been proposed as a potential solution. In many countries, smart cities are developed to increase equitable access to basic urban services, such as education, healthcare, sanitation, drinking water, and mobility (Jacques, Júnior, De Paris, Francescatto and Siluk, 2024:1). Smart cities include intelligent traffic control and advanced controls on traffic lights, connected sensor and smart meter networks for utilities and pollution and waste management AI-powered solutions that help local governments and municipalities track and manage various issues, such as illegal dumping of waste (Huawei Technologies, 2019:23).

Many African cities have started implementing smart city initiative as a way of overcoming challenges brought about by urbanisation and the need for efficient service delivery (Jacques, et al, 2024:1). For example, the Rwandan government has been proactive in promoting smart city initiatives. Rwanda's smart city development in Kigali is guided by the Kigali Master Plan for the city's future developments (Otieno & Ochieng, 2024:64). Cape Town was guided by the Smart City Strategy in 2002 which has now loosely translated to be called the Digital Strategy (Boyle, 2019). Uganda also has multiple policy and legal frameworks for implementing smart cities which include The ICT Policy for Uganda 2014, E-Government Regulations 2014 and Guidelines for E-Waste Management in Uganda 2016, among others (Otile, 2020:2). Other African countries leading in smart cities include Kenya, Egypt, Algeria, Morocco, Nigeria, Namibia and Ghana (Jacques, et al, 2024).

Climate action (SDG13)

Climate change is already having a profound effect in Africa, from the devastating floods and dry spells forcing people to migrate for survival. There is good evidence that the change in temperature has affected the health, livelihoods, food productivity and water availability. Africa has seen a decrease in rainfall over large parts of the Sahel and Southern Africa. Over the past 25 years, the number of weather-related disasters, such as floods and droughts, has doubled, resulting in Africa having a higher mortality rate from droughts than any other region (Henao, et al, 2017:58). ICTs can help to reduce greenhouse gas as emissions by enabling other sectors to reduce their emissions, smart urban lighting, facilitate smart traffic management, smart

parking, smart logistics, remote working, building energy management systems, sharing economy, smart grids, connected health, and precision agriculture (Matinmikko-Blue, 2020:20). For example, in Accra, Ghana, a team of researchers have used AI to identify buildings to assess people's needs related to climate change depending on where they actually live. AI has also been used as an early system warning to detect floods in some African Countries, such as Mozambique (Ngila, et al, 2024:2).

Peace, justice and strong institutions (SDG16)

Countries furthest from achieving sustainable human development are typically those most affected by violence and fragility. Countries most affected by conflicts and civil wars in Africa include the Central African Republic, the Democratic Republic of Congo, South Sudan and Somalia. Without peace and stability, progress on education, health and other determinants of well-being in these countries will be difficult, if not impossible (International Institute for Sustainable Development, 2016:31). ICTs helps in crisis management, humanitarian aid and peacebuilding. Growing use of open data by governments increases transparency, empowers citizens and helps to drive economic growth by record-keeping and tracking government data and local demographics (Matinmikko-Blue, 2020:20). For example, in Kenya there is Ushahidi used to map election violence using data from Twitter, Facebook, WhatsApp and SMS, among others. Other programmes include Uchaguzi, a telephone-based system and Uwiano platform for peace used to report incidents (Ngila, et al, 2024:3).

Partnerships for the goals (SDG17)

SDG17 advocates partnerships through regional and international investments and support to ensure innovative technological development. Strategies include promoting public-private partnerships, establishing multi-stakeholder platforms, strengthening Nort-South, South-South and triangular cooperations, facilitating technology transfer and intellectual property rights, and investing in capacity building and knowledge sharing (Ngila, et al, 2024:3). Partnering with a broad range of stakeholders helps to unlock the potential of digital solutions that are the drivers for sustainable development, and in managing industry-common and cross industry challenges (Matinmikko Blue, et al, 2021:1347).

Some of the partnerships and networks in Africa include the African Continental Free Trade Area (AfCFTA), which seeks to promote integration and economic growth among the 54 African states that have so far signed the AfCFTA Agreement. The AU-EU partnerships adopted a joint Innovation Agenda, which aims to transform and increase the innovative capacities and achievements of researchers and innovators. Africa-United States Science, Technology, Engineering, and Mathematics (STEM) University partnership is a joint initiative aimed at enhancing the capacity of African universities in STEM fields (Ngila, et al, 2024:3). However, there remains a huge gap in technological partnership between African countries and developed nations. Taking for instance the monopoly by developed nations in terms of transferring vaccine technology during the COVID-19 pandemic to developing countries in Africa, a move that would have increased global supply and saved millions of lives.

Challenges affecting African Countries in adopting ICTs

Lack of ICT skilled personnel

There is a lack of ICT technical skills among the population in African countries. While there may be some individuals who are proficient in using technology, overall, there is a shortage of trained professionals who can develop and maintain technological systems. This limits the ability of African countries to fully harness the potential benefits of technology (Kala, 2023:202). For instance, the ICT policy of Zimbabwe indicated that there is a shortage of ICT

skilled manpower in the country to roll out ICT programmes and for productive use of ICTs which will affect the implementation of the policy (Government of Zimbabwe, 2022:7). More so, Rwanda's ICT Hub Strategy also indicated that there is still limited human resources available for Science Technology and Innovation Development in the country due to fewer scientists coming out of the academic institutions and the low conversion of research into commercial application (ICT Hub Strategy, 2024).

Infrastructure deficit to support ICTs

Readiness to support innovation and facilitate competitive business activities requires infrastructure such as broadband Internet access, basic telecommunication services, good transportation networks, laboratory facilities, and tax systems that support private sector innovation. The AU Programme on Infrastructure Development for Africa (PIDA) revealed Africa's low scores in terms of infrastructure readiness to support ICTs (African Union Commission, 2024:18). In Kenya for instance, challenges include vandalism of ICT infrastructure, lack of a harmonised data management system and limited penetration of telecommunication infrastructure in rural areas (ICT Authority, 2020:14). In Ghana, the lack of satisfactory basic infrastructure services, such as telecommunications are currently stifling opportunities to leverage ICT for sustainable development (Huawei Technologies, 2019:30). In Rwanda, despite past efforts in growing the reach of ICT infrastructure particularly the fiber coverage and telecommunications networks, the coverage has still not reached the desired level to become a leading ICT Hub (ICT Hub Strategy, 2024).

Inadequate commercial electricity

A reliable electricity supply function is essential for powering technological devices and facilitating their usage across various sectors. However, many African countries have limited access to electricity. Without reliable power sources it is difficult for these nations to fully embrace and utilise technology (Kala, 2023:227). For example, the national power grid in Zimbabwe does not cover the whole country leaving the majority of the population with no power sources and load shedding has exacerbated the problems. The absence of power or its interruptions constitute a significant barrier to effective roll out and utilisation of ICTs across Zimbabwe (Government of Zimbabwe, 2022:16). More so, South Africa and Zambia and other African countries continues to grapple with frequent power outages and an insufficient power grid that restricts their ability to fully utilise technology (Kala, 2023:227).

Insufficient funding for ICT Programmes

The current level of investment in ICTs by Africa as a continent is very low and it puts Africa at a strategic disadvantage. Most ICT activities are not sustainable as they are over reliant on short-term project funding (African Union Commission (2024:16). Most of the collaborative ICT's initiatives involving African countries, scientists and research institutes are financed by international development partners such as the European Union and these funds are erratic and unsustainable (Namubiru-Mwaura & Marincola, 2018:43). Taking a look at Kenya's ICT policy, the execution of the ICT Authority's mandate was hampered by low financial resource capacity. This is mainly as a result of continued inadequate budget allocations across the years. The low financial allocations have led to ineffectiveness in implementation of ICT programmes including completion of on-going projects (ICT Authority, 2020:14).

Weak policies for Science, Technology and Innovation (STI) cooperation

Most of the entities responsible for STI policy making have operated in isolation from other policy agencies, with weak links not just to the private and education and research sectors, but also to African and international policy research think tanks (Namubiru-Mwaura & Marincola,

2018:43). Moreso, the majority of African countries do not have explicit policies and programmes to promote international STI cooperation and/or have not integrated international cooperation objectives into their STI policy frameworks. Only Ghana, South Africa, Nigeria and Seychelles have integrated international STI cooperation objectives in their STI policy frameworks, and only South Africa that has an institutional arrangement with dedicated resources for international STI cooperation and partnerships (African Union Commission, 2024:17).

Digital Divide

The challenge of digital divide is apparent in African countries' aspirations to adopt ICTs (Alarcon & Verheije, 2024:7). Many African countries are failing to tackle the economic and social inequalities such that the majority of the population is left impoverished. The main challenge being that, only few people can afford have access to ICTs in comparison with the less privileged. ICTs are failing to offer an inclusive environment that involves all citizens despite their economic backgrounds (Belaid & Arora, 2024). For example, there is high cost of internet prices which calls for intervention from the regulator to protect the consumers (Government of Zimbabwe, 2022:7). More so, challenges in Togo, Zambia, Malawi and Tanzania, among other African countries' ICT ecosystem include addressing the digital divide to ensure that the benefits of technology reach all segments of the population (Otieno & Ochieng, 2024:78).

Conclusion and Recommendations

The study analysed the intersection of ICTs and SDGs in African countries. The broad application of ICTs is a profound reason for optimism, since the rapid development of ICT-based services and systems offer the possibility for the needed deep transformation of the world economy and societies more broadly. The paper concluded that ICTs in Africa has contributed to creating learning opportunities for women and various marginalised groups, reduced inequalities by extending healthcare to remote areas, and providing channels for more open and transparent dialogue. ICTs have also helped to build disadvantaged communities' resilience to the effects of climate change through various local innovations and applications that improve logistics systems and market access, agricultural productivity, offer financial services like mobile money and provide early disaster warning services. However, challenges remain that affect African countries in adopting ICTs and these include lack of ICT skilled personnel, infrastructure deficit to support ICTs, inadequate commercial electricity, insufficient funding for ICT programmes, weak policies for STIs cooperation and digital divide.

It is, therefore, recommended that as far as resources are concerned, African governments should commit themselves to provide sound, predictable, reliable and sustainable financial support by setting up ICT funds. Once such funds are operationalised, the funds will help to support ICT infrastructure, ICT projects and research and innovation. This will also enable all clinics, hospitals, schools, universities, infrastructure networks, and the public administration to be connected to a high-speed broadband network which are key in realising SDGs. More so, African countries experiencing loadshedding have to invest in clean sources of energy which are reliable such as solar systems and wind turbines and ensure that there is reliable electricity which is crucial for ICTs. To add on, with regards to ICTs skill gaps, African government must take the lead in ensuring that the population is ICT ready through age-appropriate STEM education at all levels of schooling. To add on, ICTs are supposed to provide equal opportunities for all groups in the society regardless of their social-economic backgrounds.

Affordability does not have to be the determining factor in accessing ICTs hence regulating ICTs prices is crucial to avoid digital divide.

Acknowledgements
This research paper was presented at the National University of Lesotho (NUL) World Trade Organisation (WTO) Chair 3rd Annual Conference titled Bridging Borders: Technology, Trade and African Renaissance 10th – 11th October 2024 at National University of Lesotho. The research paper was also funded by National University of Lesotho and World Trade Organisation Chairs Programme.

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