Smart city technology: a potential solution to Africa’s growing population and rapid urbanization?

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ABSTRACT

Africa is rapidly urbanizing and its population is growing exponentially. The United Nations has predicted Africa will have the fastest global population growth, with over half of its populace residing in urban areas by 2050. This is concerning given Africa’s current infrastructural deficits which compromise liveability in these urban areas. Education, health, and transport are core areas of challenge in Africa and currently, no research is known to have analyzed if the infusion of smart city technology in these core areas will make a difference, a gap this paper fills. This work reviews the literature on smart city technology using Singapore as a model to make inferences and ascertain the adaptability of the technology to the African situation. It seeks to investigate the prospects of enhancing the aforementioned core areas of challenge using smart city technology and determine the prospects for Africa’s development. Findings indicate Africa’s current state of development is an advantage here as infusing core areas with digital technology would proactively help address Africa’s urbanization challenges. African nations are encouraged to embrace digital technology to address core development issues while putting adequate measures in place to maintain the security and privacy of citizens.

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Introduction

Africa is the fastest urbanizing continent. By 2050, it will be home to more than 2.5 billion people with 55% of the population living in urban centers (Güneralp et al. 2017). This urban growth is not being accompanied by the requisite infrastructural investments or policies to cater to this growth and attendant challenges (OECD/SWAC 2020). Urban centers are believed to be central to achieving sustainable development because of the significant economic potentials and opportunities they hold. However, the huge pollution emanating from cities from sources among which transportation is a major one is also a factor impacting sustainable development (Uduporuwa 2020). African countries are particularly characterized by weak healthcare infrastructure (Oleribe et al. 2019; Dekker et al. 2020), and overall lower education and literacy levels (Kasim, Wahab, and Olayide 2020; Matekenya, Moyo, and Jekе 2020). Education is a necessary tool for achieving sustainable development.

While urbanization has benefits, the possibility of urbanization to foster growth is dependent on adequate institutional and infrastructural investment (Turok and McGranahan 2013), and this is an area African countries have not performed well in. Countries like Singapore have been able to achieve great success in their urban environment with smart city technology playing a significant role in this success (Yuen 2018). Singapore’s success is particularly inspiring and portends numerous lessons for African cities to learn from especially in the light of the fact that not too long ago, it was classed as an underdeveloped third world country alongside most of the African Nations today who are still stuck in the cycle of underdevelopment. Smart city technology has been successfully deployed to achieve significant success in sectors like Education, Health, Transport, Security, Safety, Energy and, Waste Management to mention a few. This work is an in-depth review that draws on qualitative and quantitative data from peer-reviewed and gray literature to provide a concise and nuanced interpretation of the ways smart technology can be applied in national development. Here, we focus on the application of smart technology in the education, health, and transport sectors and how this can be leveraged in the fast urbanizing cities of Africa.

Literature review

A smart city is defined as

an innovative city that uses information and communication technologies (ICTs) and other means to improve
the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects. (Kondepudi et al. 2014, 13)

The core organizational fabric of the smart city embraces advancements in communications, management of data, the evolution of the Internet of Things (IoT), and an array of physical networks for the smart management of activities. The government has a central role to play in developing every smart city ranging from planning to implementing and running projects. A smart city is thus an all-encompassing urban management archetype that advances control and efficiency, facilitates participation, and promotes inclusion through leveraging and utilizing modern technologies to achieve better functioning and sustainability for all residents. A narrow understanding is to think of the smart city only in relation to technology and connectedness. In reality and principle, the smart city is about using technology to enable the government, people, and business organizations to make better-informed decisions and enhance the functioning and sustainability of society (Ponting and Yimin 2017). Smart city technology has been recognized to have an important role in achieving sustainable development in contemporary times (Kutty et al. 2020).

To this end, many cities around the globe have deployed smart technology to improve urban services and infrastructure to improve economic and social conditions, better environment, and improve their global competitiveness and attraction (Trindade et al. 2017).

Sustainable development is defined and understood in different ways in different fields; there is a consensus however that sustainable development is all about improving and sustaining a thriving and healthy social, ecological and economic human development system (Hedlund-de Witt 2014; Bhattacharya, Oppenheim, and Stern 2015; Dabi and Kporha 2015; Emas 2015; Yigitcanlar and Kamruzzaman 2015). The sustainable development of a society thereby hinges on the accessibility of quality education and services like good health care and transportation (Mensah and Ricart Casadevall 2019). Smart cities improve the lives of citizens while providing a pathway to sustainable development (Mondal et al. 2014; Gil-Garcia, Pardo, and Nam 2015). Effective deployment of smart city initiatives significantly facilitates progress towards achieving Sustainable Development (Mckinsey 2018).

**Components of a smart city**

Three layers form the foundation of the smart city. They are:

**IoT (Internet of things)**

This is the technological base and backbone made up of interconnected devices and sensors. It is a system of interrelated physical devices and objects with the ability to communicate and exchange information over a network. Its basic framework consists of electronics, firmware, software, sensors, etc. IoT has the three key features of interconnection, intelligence, and instrumentation (Mohanty, Choppali, and Kougianos 2016). Wearable devices, smartphones, smart electronics, and smart home gadgets are some examples of IoT.

**Analytics**

This refers to smart applications and data analytics capabilities for turning raw data into alerts, signals, and information end users can utilize. Analytics involves mining, manipulating, analyzing, organizing, decision-making functions. This level is the interface between the IoT and governance components.

**Governance**

This refers to the management, adoption, and usage of the information generated to inform better decisions and improve lives (Ray 2018). Governance involves meaningfully utilizing the generated information to positively change the manner people work, live, and ambulate. Governance means that the city needs to be able to combine the two other elements and administer policies necessary for smooth operations (Mohanty, Choppali, and Kougianos 2016). Smart city governance entails fashioning novel forms of collaboration by utilizing ICT to yield better outcomes and more transparent governance systems (Meijer and Bolivar 2016).

Digital technology and connectivity are the cornerstones of the infrastructural base. This is then deployed to help solve problems of sustainable development and urbanization and build a better place to live, work, and learn. This is the main goal of the smart city. African nations face the specific challenges smart technology is geared to solve making its successful infusion likely to yield positive dividends.

**Singapore’s transformation**

The evolution of smart cities in developed countries holds important lessons for developing countries to draw from (Imade 2016). Singapore’s development and transformation is drawn upon as an example in this study because of certain unique characteristics it shares with African countries compared to other western developed countries who have also actively deployed smart technology in managing urban...
growth. Singapore is a city-state renowned for its deployment of Artificial intelligence (AI), data analytics, and the IoT to make the city an efficient, safe, and liveable abode with residents achieving high levels of education, health, and mobility (Woo 2017; Kong and Woods 2018; Woo 2018). Being a forward-thinking and dynamic nation, Singapore embraced technology and invested in a massive deployment of technology which has been credited as key to the level of development Singapore enjoys today. In just half a century, Singapore elevated its status to emerge as a first-world country and a model that other countries look up to in the smart city parlance. The smart city engages all aspects of urban life including health, education, transport, safety, and productivity (Tan 2016; von Richthofen, Tomarchio, and Costa 2019).

Although Singapore is compact in size and has strong government control which enables the better implementation of policies (Low 2001; May 2004), it shares similarities with many African countries (Brenya, Adu-Gyamfi, and Warden 2017). Singapore was previously classed alongside African countries as a third-world country; it was also under the colonial government and gained independence around the same time as colonized African nations. Like the majority of African countries, Singapore is also a polyglot, multi-racial, multi-religious, and multi-cultural nation (Tan 2018). Institutional and human underdevelopment and deficits at the time of independence was also the norm for both Singapore and the colonized African countries at the time of their emancipation.

The majority of the time, western countries are used as models but it is also important to highlight the remarkable achievements of high-performing countries of other parts of the world especially those countries that African nations can relate to in certain ways. In this regard, Singapore makes a good model. Its success is also acknowledged and respected among many African countries (Soko 2020). For instance, Rwanda has modeled its development path after Singapore and has achieved some degrees of commendable success. Rwanda specifically drew inspiration from Singapore because it saw itself in Singapore in certain ways (Uwizeyimana 2019). Showcasing it as an example in this study will inspire African countries who can identify with Singapore and it, therefore, makes a better model than other places where no similar common roots can be drawn.

In this paper, we explore how digital/smart city technologies were deployed in select sectors in Singapore and how the developing countries of Africa can address challenges in education, health, and transport via smart city technology in light of its population growth and urbanization.

Singapore’s education system

Singapore made significant investments over the years to establish ICT at the core of its education system (Chen 2013). As a policy, it aimed to have the ‘best and the brightest’ citizens understanding the key role intellectual enlightenment plays in national development and embedded ICT in the root of its education system. The first IT masterplan was launched by the government in 1997 and the second one in 2002. The first aimed at providing the basic ICT infrastructure and learning environment. The second aimed to facilitate innovative, effective, and pervasive use of ICT for engaged schooling at every level (Jacobson et al. 2010). Both plans dictated the integration of ICT into the education system to proactively foster the development of a culture of learning, thinking, communication, and social responsibility deemed necessary to excel in a globally competitive labor market (Ping et al. 2003).

Singapore’s consistent high performance in the Program for International Student Assessment (PISA) is a testament to its successful ‘smart’ educational system (Suprapto 2016; Christensen 2019; Schleicher 2019), as evidenced by its 96% literacy rate, strong digital network connectivity and competitive education system (Tay, Toh, and Kaur 2019). Singapore has today, emerged as a global model in education which other countries strive to emulate.

Singapore’s health system

Singapore’s healthcare system has evolved significantly with the support of various government policies (Bai et al. 2012). In the ‘90s the Health Technology Assessment (HTA) introduced a new medical technology, evaluating the efficacy and safety of the new technology and coordination to deliver better services (Pwee 2009). In Singapore, health practitioners routinely engage with patients via Telehealth to offer support with improved outcomes (Wai Leng et al. 2014), mostly in the areas of efficiency, cost-savings, and access (Arun, Lam, and Tan 2012). Telehealth is also widely deployed in the management of chronic conditions like Diabetes. Telehealth has also proved efficient in bridging gaps and extending access to areas that had none (Ooi et al. 2015). For example, MyDoc, a pioneer healthcare platform in Singapore launched in 2012, successfully integrates various functions like virtual consultations and patient diary via video conferencing which can be accessed anywhere over the internet in a secure communication...
environment (Daruwalla, Wong, and Thambiah 2014). Today, numerous other telehealth platforms exist and provide a wide range of services further strengthening Singapore’s healthcare system.

**Singapore’s transport system**

Singapore’s transport system is powered by a technological base that provides accurate monitoring, enhances accessibility and mobility, ensures safety, reduces environmental pollution, and improves efficiency. This has made Singapore a leader in smart transportation and a reference point for other nations (Looi 2018). Three key and interdependent policies based on ICT underpin Singapore’s gold standard smart and sustainable transport system: (i) Transit-focused and compact urban environment; (ii) restriction of private vehicle ownership and use and; (iii) commitment to the continuous improvement and integration of public transport (Barter 2008; Kumar Debnath et al. 2011). Singapore boasts a robust public transport system consisting mainly of buses, a rapid transit system, and taxis. Bicycling facilities, pedestrian walkways, and the Park and Ride scheme are other additional transport initiatives ensuring access for all road users (Haque, Chin, and Debnath 2013). Electronic toll systems facilitate the road pricing policy which helps manage congestion. Enhanced technology also promotes road safety, for example, electronic devices for old people to allow more time to cross the road, the installation of intelligent traffic studs at pedestrian crossings to alert drivers when pedestrians are present at night, flashing beacons at zebra crossings, and real-time speed advisory signs (Barter 2008; Kumar Debnath et al. 2011). The advancement and infusion of smart technology into every facet of Singapore’s transport system has helped solve notable transport problems.

**Discussion**

The world is rapidly urbanizing and in 2008, for the very first time historically, more people were residing in cities than in rural areas worldwide; by 2050, over 68% of the global population will be living in urban areas concentrated mostly in Asia, Latin America, and Africa, with the fastest-growing urban centers being in Africa (UN 2018). The smart city concept holds a lot of potential for Africa, the continent most in need of sustainable development given the myriad of development challenges it is facing (Gitahi 2016). This is because it was birthed as a solution to some of the challenges that come with growing populations and urbanization (Silva, Khan, and Han 2018). African countries are keenly interested in smart solutions to control the effects of rapid urbanization as evidenced by the attendance of over 300 African mayors at various smart city summits like the 2018 Transform Africa summit held in Kigali Rwanda. There is proof of uptake of technologies by African cities to improve urban services (Erastus, Jere, and Shava 2021), and further move towards adoption in key areas will drive positive growth. There is compelling and immediate evidence that smart city policies may help address problems that plague traditional rapid urbanization patterns (Estevez, Lopes, and Janowski 2016). The question of how smart technology can be deployed by African cities in the education, healthcare, and transport sectors are answered below.

**Education**

Education is key to the sustainable development of nations but Africa’s current education system lags in this core area (Uleanya et al. 2019). Countries in every part of the world, despite the level of development, are making inroads into the infusion of ICT in schools to better prepare the youth for the digital age (Choy and Ng 2015; Gonen, Sharon, and Lev-Ari 2016). The use of ICT tools in the educational system can increase the productivity and efficiency of teachers (Akarowhe 2017). Carving out specific and goal-driven ICT policies to have enlightened and well-educated citizens in line with Singapore’s ‘Best and Brightest’ or ‘Smart Nation’ initiative is just one way to foster education. The use of ICT in education promotes access to world-class quality content; enables a better and more educated populace; provides access to low-cost teaching resources and enables interactive, synchronous two-way content (d’Aiglepierre, Aubert, and Loiret 2017). Common tools employed by teachers in the developed world include lesson preparation and authoring tools, student tracking tools, learning management systems like Blackboard, and test service systems (Ünlü and Wang 2017). For students, ICT promotes increased learner collaboration and engagement (Tay and Wang 2016).

Some innovations in ICT in Africa like Worldspace, Eneza, and eGranary are helping improve education. Worldspace is a technology used in Kenya to broadcast learning content to more than 10 million pupils in 21,000 primary and secondary schools (Mwangudza et al. 2013). Eneza Education is an ed-tech company operating in Kenya, Ghana, and Ivory Coast that enables students to access revision and learning materials. Over 6 million learners accessed Eneza’s resources with over 23% learner improvement within
nine months (Winthrop and McGivney 2015). eGranary Digital Library provides digital learning materials to schools that lack sufficient internet access. eGranary obtains permissions to duplicate websites and distributes them to intranet servers of the partner institutions in developing countries (Gafinowitz 2016). A lot of higher education institutions in Africa are using eGranary to improve learning outcomes for students. These technologies are helping to circumvent poor internet access and enable African universities to access international libraries (Norton, Early, and Tembe 2010). Further deployment of similar smart technology will certainly help improve access to education as evidenced by the given examples. Hopeful trends on the informal use of mobile Internet by students and teachers to augment classroom learning has already been seen in rural Sierra Leone (Samarakoon, Christiansen, and Munro 2017). Just as ICT has helped and formed a core part of Singapore’s education system, working towards the same in Africa will ensure exponential growth in the education sector and overall development.

**Healthcare**

The majority of African countries rank very poorly in the healthcare sector which is compounded by a shortage of doctors and inadequate health infrastructure (Arun, Lam, and Tan 2012; Deaton and Tortora 2015). Disease burden is high and healthcare is underfunded in Africa (Gouda et al. 2019). Technology in the form of telehealth has the potential to bridge this immense gap and ensure access among the diverse and remote population as is being done in Singapore where its vulnerable aged population is served in the comfort of their homes. The increasing mobile penetration in Africa can accelerate growth in the fledgling health sector and overcome the lack of physical infrastructure (Adeola and Evans 2018). The current gap in health policy could serve as a bonus in the quick adoption of technology without policy restrictions (Alonge 2017).

There is already some promise as smart technology is already used to some degree in countries like Nigeria (Lovitske 2018). Aajoh, a health tech firm in Nigeria uses Artificial intelligence (AI) for fast and remote medical diagnoses where patients input their symptoms in the app and receive a diagnosis alongside information on where to purchase drugs. Information on where to procure prescribed drugs is important because of the proliferation of fake drugs in Africa which has caused a lot of deaths. Doctors become freer to treat patients in need of in-person care and access to healthcare is widened. AI is helping to bridge the infrastructural gap. For example, LifeBank utilizes digital supply chain technology to deliver life-saving medical supplies like blood to where it is needed in Lagos, Nigeria. MTRAC is an SMS-based technology that connects hospitals in Uganda to the national drug chain and is used by government health workers in Uganda to report on medicine stocks. Other areas that could be explored include chronic disease management like diabetes; as diabetes technology tools like continuous glucose monitors and insulin pumps have proven quite effective in managing diabetes (Allen et al. 2017).

The internet has emerged as a cost-efficient and practical information source providing people access to healthcare material that might have been otherwise inaccessible (Massey 2016). The government uses the internet in Singapore to provide information to health practitioners and users alike. Information on necessary medical procedures is provided to citizens in the government’s health portal in a bid to help them save cost. The use of ICT in health presents a chance for building stronger health systems to ensure better service delivery (Balikudembe and Reinhardt 2020). In Africa, there are still gaps in taking advantage of the health information available on the internet generally. Access is marred by unreliable internet connection, high cost of internet access, and power problems despite the willingness of the people to use the internet (Obasola and Agunbiade 2016). There is a need to address these mitigating factors. In a study investigating the use of the internet for health information among healthcare professionals in Nigeria, despite the very high level of internet literacy among respondents, usage of e-resources was very limited as 85.7% of the respondents did not take advantage of the knowledge available on the internet. Slow internet connection, poor awareness of available digital resources, and lack of subscription to e-databases for the most up-to-date resources by health institutions were some of the factors identified as militating the usage of ICT by health professionals (Oriogu, Subair, and Oriogu-Ogbuji 2017). Smart technology indeed holds the potentials to bridge the healthcare gap in Africa.

**Transportation**

Transportation is a major pollution source in urban centers globally (Agarana, Bishop, and Agboola 2017; Hoffmann 2019; Schäfer and Yeh 2020). The denser or more populated the city, the greater the pollution especially in African urban centers due to the higher number of vehicles and reliance on road transport (Naidja, Ali-Khodja, and Khardi 2018; Katoto et al. 2019). Singapore’s transport system is venerated as among the best in the world (Debnath et al. 2014).
Many other countries have also sought to improve their transport sector using Singapore’s model and African cities can certainly draw lessons from Singapore’s transport sector given its poor Urban Transportation Infrastructure (UTI) (Kumar and Barrett 2008; Berg et al. 2017). UTI is an important asset for cities because of the impact on urban functioning. Africa’s urbanization and population growth have made this need for UTI even more paramount because of the need for sustainable mobility which impacts economic growth (Chatzioannou, Alvarez-Icaza, and Galatioto 2017). There is a huge deficit in transportation infrastructure which has made congestion a hallmark of African megacities like Lagos in Nigeria (Ukpata and Etika 2012). It is not uncommon to spend 5 hours daily on the commute in Lagos. Getting to work is an arduous task in most of Africa’s cities as a result of the dysfunctional urban transport system. The cost of traffic congestion amount to billions of US dollars and cities with congestion problem lose investment to less congested areas (Newman 1996; Bamwesigye and Hlavackova 2019).

Smart city technology could help improve traffic congestion and poor public transport and road systems. Pedestrian crossing and pedestrian traffic light are mostly inexistent despite walking accounting for more than half of trips in cities like Kinshasha, Conakry, and Douala. It is therefore not surprising that pedestrians make up two-thirds of all road-related fatalities in the cities of Africa (Arimah 2017). ICT has the power to deliver positive changes and bridge the current infrastructural gap, freeing up time for skilled labor which equals more productivity (Lovitske 2018). Intelligent Transport systems can help in reducing the impact of congestion in cities. For instance, advanced traveler and traffic management systems can predict congestion and proffer alternative route options to vehicles in real-time and improve the efficiency of travel. Such a system can also offer information to vehicles and travelers on the best time to leave their homes, traffic accidents, weather conditions, etc which will enable them to take the best options. Developing African countries can install the necessary digital technology at the same time physical infrastructure is being built which is cheaper than retrofitting as would be the case for developed countries wishing to upgrade or roll out new technology in these areas (Pojani and Stead 2015).

Intelligent solutions can solve the existing transportation problems by improving the efficiency and allocation of resources across the various forms of transport. In India, there is a GPS installed Bus Rapid Transit System (BRTS) which has helped in improving public transport and reducing carbon emission (Kathuria et al. 2016). More than 127 million people use the BRT system annually which has greatly improved transportation services. India’s solution was modeled after the successful rollout of similar technology in Italy and Brazil but the Indian version has been voted the world best in terms of efficiency. This is to illustrate how possible it is to piggyback on technological successes elsewhere. Some cities of Africa already have BRT systems in place but there is still room to improve through the infusion of technology to better manage the system. Examples of areas that will benefit from smart technology adoption include traffic flow, parking, and pedestrian management (facilities for cycling and walking). Integration of technology in environmentally friendly transport like public bicycle systems and bike-sharing are also possibilities (Bamwesigye and Hlavackova 2019). An improved transport system will enable cities to harness the benefits of agglomeration in urban centers and become more efficient. A paradigm shift is indeed necessary for African cities to achieve sustainable development in the transport sector.

Security and privacy concerns, control and mitigation

Progressing Africa to digital smart city solutions needs to be a continuous and measured process and efforts to make it safe and secure could be achieved by: (i) Cybersecurity; (ii) Testing and continuous improvement; (iii) Anonymization and aggregation of data; (iv) Decentralization (v) Licensed Professionals handling systems and white hat hacking.

Cybersecurity

Open data is key to the success of smart city programs (Barns 2016), but interconnected digital systems also carry a high risk of data security making it imperative for every smart city strategy to have a strong cybersecurity component (Berger 2017). There is the risk of privacy invasion but for AI systems to work, citizens must share information. When they don’t because of privacy concerns, there are constraints on data deployment to solve problems. People face a trade-off between protecting privacy and benefits accruable from broader scopes of data use. IoT indeed provides an enormous interface for hackers to strike and infiltrated security networks pose very grave risks if hackers attack. Remote control of medical devices and compromising of medical monitors could lead to the death of patients (Anandarajan and Malik 2018). The hijack of self-driving cars is also a dangerous possibility. Secure infrastructure is necessary for the transformation
of African cities to smart cities (Erastus, Jere, and Shava 2021). High levels of security must be in place before critical IoT applications are deployed and a plan to respond to such breaches must be in place and constantly reviewed in line with changing realities.

**Testing and continuous improvement**

To reduce the security and privacy risks associated with smart city technologies, the smart systems need to be effectively tested, deployed, monitored, and supervised (Mark 2017) especially given recognized concerns like system failure which could have a significant impact (Lacinák and Ristvej 2017). Nothing must be deployed that hasn’t been tested and demonstrated as safe to use.

**Anonymization and aggregation of data**

Making the data collected by smart city applications open and public is a way to reassure the people of transparency (Woherem and Odedra-Straub 2017). Anonymization and aggregation of data de-identifies data enhancing privacy. Building citizen’s trust and openness increases trust and engagement levels. Singapore is modeled into an open-source society renowned for high levels of transparency, trust, and openness even as independent consultants are contracted to audit the system to ensure that its integrity is maintained (Soppouris 2016).

**Decentralization**

Decentralization of systems is another way to mitigate risks by ensuring that pockets of technology are scattered and not in one central location which increases the risk of attack and things going wrong on a wider scale if the central system goes wrong. Some solutions are possible with only local communication example signboards showing available parking spots. Wherever possible, if the data needed to make things easier is local and doesn’t need centralization to work, there is no need for centralization. Such solutions reduce the complexity of smart systems.

**Licensed professionals handling systems and white hat hacking**

The experts who manage smart systems must have certain minimum and regulated competency standards because malfunctioning of smart systems could result in grave consequences like the loss of lives. Certain programming must be done by only licensed professionals who have proven competencies. White hat hacking, also known as ethical hacking involves proactively working to detect and fix bugs and flaws in the system before cybercriminals discover and take advantage of the bugs (Al-Sharif et al. 2016). Ethical hackers could be engaged to improve the security of smart systems.

These are some security measures advocated for the developing African countries eager to hop on the smart city train. Smart city opponents are mainly concerned about government surveillance, the privacy of citizens, and other digital rights.

**The way forward**

While the areas which form the core of this study are not the only areas that need attention to achieve sustainable development in Africa, they are nevertheless important and will drive improvement in other areas. Two angles to Africa’s rapid population growth and urbanization are that its high growth rate can perpetuate existent inequalities and poverty and inhibit growth; and its position to use smart technology to foster economic development and promote sustainability (Huet 2016). African cities might be seen as falling behind the curve but the wide adoption of digital technologies has the potential to change the paradigm (Lee 2014). Despite the attendant risks associated with smart city technology, experts ultimately agree that the adoption of smart city initiatives will enormously improve human lives (Geib 2017; Bibri 2019; Bibri and Krogestie 2019). The smart city system ensures the integration and optimization of urban infrastructure systems beyond like water, sewage, energy, transport; it also promotes efficiency in the management of these systems as well as the resolution of human-capacity and environmental issues (Hancke and Hancke 2013; Bibri 2019). The penetration rate of smart technology is still low in Africa (David and Grobler 2020), with the implication that the potentials they portend for development are not being adequately harnessed. Significantly, there is evidence of ICT integration enhancing competitiveness and being positive for economic growth and development in Africa (Solomon and van Klyton 2020). While ICT investments involve huge capital, African countries are positioned to benefit immensely from investments because it is home to the world’s youngest population. Africa contributes 37% of the global youth population (Ude 2020), with an average age below 20 (Diop et al. 2020). This youthful population brings with it a lot of potentials in the successful uptake of smart technology as young people have proven to be more adept and accepting of new, modern smart technology.
movement and 80% of goods in Africa (Sabar and El Hammoumi 2020). Smart transportation will make a significant impact by reducing congestion, increasing safety, reducing transfer cost, improving the speed of transfer, and reducing pollution (Peprah, Amponsah, and Oduro 2019). For education, primary school enrollment is not yet 100% and secondary enrollment was only 28.3% in 2017 (Begashaw 2020). ICT technology can make education more accessible for remote populations where there may not be physical schools.

‘Africa Rising,’ a term coined to reflect positive growth and development strides by the media is replacing the negative impoverished region stereotype long associated with Africa (Brooks 2018). With the ‘Africa Rising’ account gaining traction, visions of urbanization need to be examined, especially given the continent’s rapid population surge (Slavova and Okwechime 2016), particularly in its cities. Despite Africa’s rising, regrettably, six of its cities ranked poorest in the 2018 liveability index, while five African cities made it in the list of least liveable cities (Kunnguyu 2018; EIU 2019). While cities are a magnet of talent, productivity, and innovation which can yield immense economic value, an adequate institutional framework can help to redesign cities around smart solutions to achieve sustainability (Akuboji, Nwakanma, and Ekeocha 2017; Engel, Berbegal-Mirabent, and Piqué 2018). Developing African nations can set themselves apart with a strong drive to succeed, good vision, and management as they now have the opportunity to simply adopt what has proven successful elsewhere saving huge initial development costs in the process; as well as building new cities from the scratch with these technologies as seen in Kenya’s Silicon Savannah and Lagos’ Eko Atlantic city. Such approaches give the luxury of a blank canvas to explore and design solutions to suit unique citizens’ needs without the hassle of retrofitting. Smart cities offer much more benefits than risks and if done right will deliver solutions for more efficient, cleaner, and safer lives as long as we employ the same levels of defence for data that we do for our homes and precious belongings. However, there should be a balance between the need to advance quickly and achieve economic gains and transition time to engage with citizens in order for them to grasp new concepts and accept them as well as cautious testing and validation of new systems. Education and public engagement are key to enable citizens to understand changes in how things work in a smart city and serve as a feedback medium to improve solutions.

**Conclusion**

Cities all over the world are striving and under pressure to improve services to their residents, increase efficiency, reduce operational costs, address transportation and congestion problems, and promote competitiveness. To achieve these goals many nations are turning to smart solutions because of the myriad of opportunities they offer to address development needs. There are endless opportunities for Africa as its urban centers are at the cusp of speedy development in various ways giving its cities the rare chance to initiate and pilot a new era of thinking which will yield quantifiable benefits to its citizens.

Smart technological applications provide the means for African cities to help solve their needs and leapfrog other nations in their development. Embracing smart city technologies for African cities is a necessity for global competitiveness. Asides from the core areas that form the focus of this paper, Smart city technology can also be deployed to improve security and safety, energy use, security, and waste management while encouraging citizen participation and inclusion in governance. Seeking a smart city development pathway is an important strategic pathway with many prospects. Africa’s rapid urbanization pace makes it imperative to apply digital technologies in city administration to improve resource allocation (Shell 2014).

Smart cities are a holistic and workable framework that can help African nations achieve their development goals and the continent is well-positioned to take this journey and achieve success given its youthful populace is more than eager to adopt new technologies. The fact that Singapore, a country that barely half a decade ago, had a similar profile and developmental challenges as many African countries but has evolved into a first-world country with the deployment of technology is proof that Africa can achieve this. Africa can learn from other experiences, replicating their successes/achievements, and avoiding their mistakes. The benefits of embracing technology are legion and transcend into spheres like utilizing the big data generated from social activities to improve safety and security, transport services, public health problems, energy use, and waste management. The new era of low-cost digital technology provides Africa with an opportunity to engage better in the global market. Combined with its youthful population, a new dawn may just be here for Africa, all thanks to digital technology. Advancing the smart city solution for Africa seems like a viable way forward as long as the necessary checks and balances are in place.

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