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Smart Cities and Regional Development: The Role of Digital Infrastructure in Enhancing Regional Competitiveness in Ghana

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Abstract: ***Enhancing smart cities and regional development require leveraging on digital tools and technologies to build liveable cities. Population growth in recent times does not commensurate regional planning and development, resulting in congestion and blur competitiveness. The study empirically examines the concept of smart cities, focusing on how digital infrastructure can enhance regional competitiveness. It also identified the key challenges that Ghana faces in implementing these strategies and provide insights into how these obstacles can be overcome. Findings highlights the rapid population growth which has both positive and negative effects. The positive side enhances human resources and social capital, which is crucial for socio-economic progress. However, the negative aspect creates rising demand for energy, water, sanitation, education, healthcare, housing, transportation, and public services, putting immense pressure on city infrastructures. Successful implementation involves tackling pervasive issues such as governance inefficiencies, limited public-private collaboration, and the digital divide between urban and rural areas. Digital infrastructure serves as the foundation for contemporary and innovative economy. Therefore, advancing digital transformation and smart city strategies in Ghana requires addressing broader socio-economic challenges such as traffic congestion, urban sprawl, air pollution, and ecosystem degradation. Investing in education, infrastructure, and inclusive policymaking would be critical to overcoming these hurdles and ensuring the successful realization of smart city objectives in Ghana.***

Keywords: smart cities, digital infrastructure, challenges, implementation strategies, Ghana

1. Introduction

With urban populations growing at an accelerated rate worldwide, cities are facing numerous challenges related to overcrowding, resource management, climate change and public service delivery. Enhancing smart cities and reginal development require leveraging on digital tools and technologies to build liveable cities, manage city growth and sustainable climatic conditions, as well as accelerate economic growth. In Ghana, cities like Accra, Kumasi, and Takoradi are witnessing rapid urbanization, with more people flocking to urban centers in search of better opportunities and access to resources (World Bank, 2015; Puplampu & Boafo, 2021). While this growth presents a chance for economic progress, it also brings about significant challenges, particularly in infrastructure and governance. As a result, the concept of smart cities has become increasingly relevant tool for Ghana's urban development strategy.

A smart city may refer to an urban area that uses digital technologies, data, and innovation to enhance the quality of life for its residents, improve public services, and drive sustainable development. These cities rely on digital infrastructure such as high-speed internet, sensors, cloud computing, and data analytics to optimize everything from traffic flow to waste management, making systems more efficient and responsive. For Ghana, embracing the smart city model offers a way to tackle pressing issues like congestion, inadequate public services, and inefficient resource use, while also providing a pathway for growth and development.

At the core of any smart city is digital infrastructure, the systems that allow cities to function intelligently. From smart grids to Internet of Things (IoT) devices, these technologies enable better urban management, create economic opportunities, and improve the overall quality of life for residents (Mensah et al., 2023). For Ghanaian regions, investing in digital infrastructure can significantly boost competitiveness by attracting both local and foreign investments, enhancing service delivery, and fostering innovation within businesses and industries. Digital infrastructure can improve urban planning, making cities livable and sustainable in the end (Qin et al., 2024; Wang, Zhai & Zhang, 2024).

Ghana's transition to smart cities faces a number of challenges. There are significant gaps in the current infrastructure, limited financial resources, and a lack of skilled labour to develop and maintain these advanced technologies. Moreover, the country does not yet have a comprehensive policy to guide the implementation of smart city strategies. Addressing these issues will require collaboration between the government, private sector, and local communities, as well as a long-term commitment to investing in infrastructure and human capital.

This paper aims to examine the concept of smart cities in the Ghanaian context, focusing on how digital infrastructure can enhance regional competitiveness. It identified the key challenges that Ghana faces in implementing these strategies and provide insights into how these obstacles can be overcome. By doing so, this paper highlighted the potential of smart cities to foster regional development, improve governance, and position Ghana's urban centers as more competitive on the global stage.

The concept of population growth versus urban planning and development

The world is experiencing rapid urbanization, and it is even swifter in developing countries including Ghana where population growth far exceeds infrastructural development and urban planning. The predicted urban population growth is equivalent to approximately 3 billion urbanites by 2050, much of which would occur in Africa and Asia. According to world cities report by World Bank Group, the global urban population is projected to increase 68% by 2050, at which point nearly 7 in 10 people would live in cities. The rapid growth is driven by rural-urban migration, which resulting in urban sprawl and slum development as well as the development of high quality infrastructure and overall improvement in the standard of living. This is potentially going to have serious implications on land use, resource allocation, urban development and planning as well food security.

The fastest population growth will occur in megacities with over 20 million people, with at least 13 new megacities expected to emerge by 2030, joining the 28 already in existence. The most rapid urban growth will be seen in cities with around a million inhabitants, primarily in lower-middle-income countries in Asia and Africa. This rapid urban expansion presents significant sustainability challenges. The rising demand for energy, water, sanitation, education, healthcare, housing, transportation, and public services is putting immense pressure on city infrastructures. In 2015, 828 million people lived in informal settlements without basic services such as sanitation and access to clean water, with six million more people moving into such conditions each year. Cities account for 67% of global energy demand and consume 40% of the world's total energy, while contributing to 70% of global greenhouse gas emissions, exacerbating climate change. Moreover, urban areas are increasingly facing natural disasters and social tensions driven by rising inequality, unemployment, pollution, traffic congestion, and urban violence.

Research by Antwi-Afari (2022) highlights that the rapid global population growth has both positive and negative effects (Ojo et al., 2014). On the positive side, population growth enhances human resources and social capital, which are crucial for socio-economic progress (Ratti & Townsend, 2011). However, it also brings numerous challenges, such as rising unemployment, increased pressure on public services, traffic congestion, social issues, poor healthcare, an underperforming education system, housing shortages, ineffective waste management, higher energy use, and greater greenhouse gas emissions (Nautiyal et al., 2018). These challenges linked to population growth and urbanization may be mitigated through the adoption of the smart city concept (Chatterjee and Kar, 2018).

Africa is undergoing rapid urbanization, marked by the highest urban growth rate globally at 3.3% per year between 2000 and 2015, with an urbanization level reaching 40% in 2018. Currently, approximately 500 million people in Africa reside in urban areas, and by 2036, this is expected to exceed half of the continent's population (52%). This transformation has led to the rise of many large cities, including 55 with populations over one million and four megacities. This urban growth creates economic prospects through economies of scale and agglomeration, it also demands significant investment in infrastructure to address growing needs for water, sanitation, energy, transportation, and public spaces. Moreover, effective governance and policies are essential for managing social challenges, promoting equitable access to education and healthcare, and addressing insecurity and violence. Notably, this urban expansion aligns with advancements in information and communication technologies (ICTs), which are improving the efficiency of goods and services production and enhancing connectivity between urban centers (Mboup & Oyelaran-Oyeyinka, 2019).

The concept of a smart city

According to (Slavova & Okwechime, 2017), while refining the concept of a smart city has its value, their research focuses on understanding how smart cities can enhance urban well-being in Africa and support Agenda 2063 through practical, evidence-based approaches. By reviewing various smart city implementations, they propose a pragmatic understanding that categorizes smart city interventions into 'hard' infrastructure (e.g., energy, transportation, and buildings) and 'soft' infrastructure (e.g., governance, social cohesion, and education). Information and communication technologies (ICTs) play a significant role in both domains. In hard infrastructure**,** ICTs support applications such as energy management, transportation systems, public safety, and environmental monitoring. In soft infrastructure**,** they address issues related to education, cultural integration, social participation, governance, and welfare. This framework provides a lens through which the smart city concept can be leveraged to tackle the specific challenges faced by African urban areas.

According to (Antwi-afari et al., 2021), Ghana's rapid population growth and urban expansion have led to challenges such as traffic congestion, high energy consumption, inadequate waste management, and increased pressure on housing (GSS, 2014). To address these urbanization issues and transition cities in developing countries toward smart city development, various initiatives have been introduced. In Ghana, government programs such as the railway redevelopment project, the Free Senior High School program, and the One District, One Factory initiative aim to improve mobility, stimulate the economy, and enhance the overall well-being of citizens (Government of Ghana, 2019).

The role of digital infrastructure in promoting regional competitiveness.

According to Ummah (2019), the digital infrastructure of contemporary cities is becoming a more prominent aspect of daily urban life. Sensor technologies are being integrated into urban infrastructure, enabling information processing to be seamlessly embedded within the physical environments of cities.

According to Stankovic et al. (2021), robust digital infrastructure serves as the foundation for nearly every aspect of a contemporary and innovative economy and society. Digital competitiveness, as part of the broader concept of competitiveness, is a multifaceted construct. It includes elements such as the capacity to learn and adopt new

technologies, technological enablers that facilitate digital transformation and readiness factors that evaluate the preparedness of both the economy and its citizens to embrace digital transformation.

According to Brunetti et al. (2020), digitalization, the digital revolution, and digital transformation have become widely discussed topics in recent years. However, it raises the question of why these conversations are only now gaining momentum. For over five decades, information technology (IT) and related research have achieved major milestones, including electronic data processing, personal computing, communication technologies, the Internet, and social media, all of which began in the mid-20th century. Nonetheless, recent developments such as big data, artificial intelligence (AI), and Biocomputing have reignited interest in digitalization and digital transformation, marking the dawn of a new IT era. Today, digital transformation is all-encompassing, influencing every sector and organization. The continuous presence of information, knowledge, and processing capabilities, coupled with the increasing interconnectivity of people, objects, devices, and systems, is transforming how individuals, businesses, and societies operate.

The shifting toward a digital economy could partially address economic improvement and enhance service accessibility in rural areas (Shavazipour et al., 2021). This is particularly important for advancing education and healthcare services. While faster internet technologies can help bridge the digital divide, improved connectivity alone is insufficient. Rural communities also require digital skills and competencies to fully benefit from these advancements.

The perceived advantages of adopting smart city concepts are motivating numerous cities worldwide to enhance urban structures in pursuit of achieving smart city status (Lam & Yang, 2020). However, a key question persists: how can cities assess their current level of smart development and improve urban systems through the lens of smart city principles? Leveraging a "lessons learned" approach, where cities implement policies based on the experiences of established smart cities, could enhance the performance of underdeveloped urban areas. Nonetheless, cities are unique, shaped by factors such as culture, politics, environment, climate, and natural attributes, which vary significantly across regions (Antwi-Afari et al., 2021; Martin et al., 2018). As such, insights from other smart cities can serve as a starting point, but underperforming cities must ultimately develop customized solutions tailored to their specific needs (Chatterjee & Kar, 2018).

In summary, robust digital infrastructure not only fosters regional competitiveness by enhancing connectivity, innovation, and service accessibility but also serves as a critical enabler of sustainable urban and rural development.

Key challenges in implementing smart city strategies in Ghana.

To evaluate the smartness or development levels of cities, various organizations, both independent and governmental, have established criteria and indices. For instance, in 2000, the Economist Intelligence Unit (EIU) introduced a digital economy ranking to measure countries' readiness to adopt information and communication technologies (ICTs). Similarly, the World Economic Forum (WEF) launched the Global Competitiveness Index (GCI) in 2005, and the World Intellectual Property Organization (WIPO) developed the Global Innovation Index (GII) to rank cities globally (Akande et al., 2019; Albino et al., 2015). However, these indices often fail to capture the full spectrum of dimensions within urban spaces, such as mobility, economy, environment, living conditions, governance, and societal well-being (Antwi-Afari, 2019). For Ghanaian cities like Kumasi, this limitation underscores the need for tailored frameworks that reflect local urban realities.

Cities in developing countries, including Ghana, face significant urbanization challenges such as traffic congestion, urban sprawl, air pollution, and ecosystem degradation. For these cities, the objective is to identify critical structural problems and propose tailored solutions that enhance overall urban prospects (Antwi-Afari et al., 2021; Webb et al., 2016). In Kumasi, for example, using a six-dimensional framework adapted from models applied to medium-sized cities in Europe can help pinpoint areas requiring improvement to foster development, resilience, smartness, and sustainability. Yet, implementing such frameworks faces numerous barriers, including limited financial resources, policy misalignment, and governance issues.

A critical challenge in implementing smart city strategies in Ghana is the economic appraisal of such initiatives. According to Type and Prathivadi (2022), under optimal conditions, smart city projects should undergo cost-benefit analysis similar to other public infrastructure projects. However, there is limited research and guidance on this, apart from studies focusing on smart grid systems. Assessing the value of interventions like cloud platforms or knowledge hubs is particularly challenging because their benefits are often intangible and not immediately apparent to end users. This suggests a need to develop valuation methods tailored to the Ghanaian context, such as contingent valuation and qualitative approaches.

Moreover, digital skills development is another pressing issue. Brunetti et al. (2020) emphasize the importance of equipping businesses, public administrations, and educational institutions with updated digital competencies. While younger generations in Ghana often exhibit intuitive technological proficiency, experienced workers frequently require specialized training to bridge the gap. Unfortunately, educators and training institutions may lack the necessary digital expertise, hindering effective knowledge transfer. This highlights the need for investments in capacity-building initiatives that align with Ghana's unique socio-economic context.

Finally, advancing digital transformation and smart city strategies in Ghana requires addressing broader socio-economic challenges. Beyond technological upgrades, successful implementation involves tackling pervasive issues such as governance inefficiencies, limited public-private collaboration, and the digital divide between urban and rural areas. Investing in education, infrastructure, and inclusive policymaking will be critical to overcoming these hurdles and

ensuring the successful realization of smart city objectives in Ghana.

2. Conclusion

The development of smart cities represents a transformative opportunity for addressing the challenges of rapid urbanization and fostering sustainable regional competitiveness in Ghana. By leveraging digital infrastructure, Ghana can enhance connectivity, improve public services, and stimulate innovation across key sectors. However, achieving this vision requires addressing significant challenges, including gaps in infrastructure, policy alignment, governance inefficiencies, and the need for capacity building.

A smart city framework tailored to Ghana's unique socio-economic and cultural context can guide urban development efforts. This includes implementing solutions that balance global best practices with locally developed strategies, ensuring inclusivity, and addressing the needs of both urban and rural populations. Moreover, targeted investments in education, digital skills development, and collaborative governance structures are critical for enabling effective implementation.

Ultimately, the transition to smart cities in Ghana has the potential to not only improve the quality of life for its citizens but also position the country as a competitive and resilient player on the global stage. By adopting a strategic and collaborative approach, Ghana can unlock the full potential of digital transformation and secure a sustainable future for its regions and cities.

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