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Exploring Barrier-Free as a Catalyst to Smart Cities Initiatives in Sub Saharan Africa

Joseph A. Danquah, Alexander B. Marful, Daniel Duah

(Arc. Joseph A. Danquah, CSIR-Building and Road Research Institute, Kumasi-Ghana, joedanquah@gmail.com)
(Dr. Ing. Alexander B. Marful, Kwame Nkrumah university of Science and Technology, Kumasi-Ghana, abmarful@yahoo.com)
(Dr. Daniel Duah, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana, duahdani@gmail.com)

1 ABSTRACT

The Sustainable Development Goals and the UN Conventions on the Rights of Persons with Disabilities both strive to make all cities and human settlements inclusive, safe and resilient without discrimination. Actions through policies, legislation and advocacy have been employed by Sub-Saharan Africa (SSA) governments to achieve barrier free environments with little progress. Smart community initiatives can become a potential conduit for speeding the development of barrier free environments in these countries. The study thus explores the concept of barrier free as a catalyst in smarting communities' initiatives in Africa. An exploratory mixed methods approach is used through the review of epistemological assumptions of smart communities and surveys of perceptions of people from the university community. Case studies of selected smart city initiatives and smart university campuses were reviewed, and KNUST (as a microcosm of a city) with a population of 50,000 was used as a case study. The study revealed the silent nature of current smart city characteristics on barrier free features whilst technology and people remain the backbone of inclusive smart community initiatives. Again most respondents are optimistic of its success in SSA, though cautioning its cost. A low smart index score of 36.9 was recorded on the KNUST Campus. This study provides vital data to policy makers on implementation of integrated barrier free and smart community initiatives in Sub-Sahara Africa.

Keywords: Smart Community, Smart Cities, Barrier Free, Disabilities, Inclusive

2 INTRODUCTION

The world's population which currently stands at 7.66 billion is projected to reach 8.6 billion by 2030. The increase is expected to be accompanied by a similar rise in urban population (United Nations World Population Prospects UN-WPP, 2017; Worldometers, 2018). The World Health Organisation (WHO) projects the percentage of world population with some form of disability to be between 10% and 15%, with 2.4% having a severe form of disability (World Health Statistics (WHO), 2011', International Classification of Functioning, Disability and Health (ICF)', 2018). The increasing percentage of disability is due to the ageing population. The UN Convention on Rights of Persons with Disability (CRPD) passed in 2008 gives credence to the urgency of making inclusive environments for all, irrespective of any form of disability. This has become a human rights issue which has shifted the paradigm from the traditional charity oriented medical approaches to disability (UNHCR 2016). Despite the foregoing, countries continue to struggle to improve and remove the existing barriers due to factors ranging from economic to physical, political, social, cultural and psychological. Countries in Sub-Saharan Africa continue to lag behind in ensuring barrier free environments as it is one of the least developed regions in the world. Amongst the solutions to the removal of barriers is the emerging technological advancement in the world through smart city initiatives. A global survey conducted in 2016 involving over 400 specialists, agreed that smart city initiatives would help remove barriers for persons with disabilities (PwDs) with mobile technology seen as the most promising technology to promote the inclusion of cities worldwide (Clarke et al. 2014). Sub-Saharan Africa is undergoing a digital revolution and is predicted to be the fastest growing mobile subscription base in the world (GSM Mobile Economy Report Series, 2015; Ericsson, 2014, 2015). By 2020 about 720 million smart phone users will be in Africa. The rising trend is due to high investments in deep sea cable installations to increase the Internet of Things (IoT), the people and smart technology (Rice-Oxley and Flood 2016). This development has made many tasks easy for PwDs through the use of assisting technology worldwide (Clarke et al. 2014).

Ghana has been struggling to build environments free of barriers to meet international standards for years, due to several factors including finance, legislation and enforcement, culture and education as most critical. Eleven years since the passage of the Disability Act 715 upon the expiration of the ten year moratorium, the level of compliance is abysmal with the government being a major culprit. For instance, a recent international workshop labelled "parliament without barriers" (PAMBA) assessed the compliance levels of

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Ghana's legislature as to provisions of the act and barrier free ones generally. It was found that major barriers existed in the parliament building that needed attention (Marful, Duah, and Danquah 2018). With the increasing penetration and use of smart mobile technology in Ghana, the adaptation and usage of the technology could be a panacea to removing barriers in the built environment, and thus set the premise for the speedy initiation of smart city concepts in the country. Whilst the benefits far outweigh the challenges it will further ensure that the country meets the UN sustainable development goal of making cities inclusive and resilient a reality.

2.1 Theoretical framework

Disability Models

Disability has many models from varying disciplines traversing all walks of life and includes the following : (1) medical model of disability; (2) moral model of disability, (3) social model of disability, (4) expert/professional model of disability, (5) tragedy model of disability, (6) legitimacy model, (7) empowering model, (8) social adapted model, (9) economic model, (10) and market model, (11), new paradigm model, (12) spectrum model, and (13) assistive technology model (DePoy & Gilson, 2014, Brandsma and Van Brakel, 2003). The most widely used are the medical and social models of disabilities which deal with disability caused by a disease or trauma and disability caused by the barriers that society has imposed on people respectively. WHO (1980) recognises the following nine classes of disability, namely vision, hearing, memory, movement, mental health, thinking, communication and relationships. Thus, WHO highlights a mix of two models - medical and social disability as contained in the international classification of function (ICF) definition. This mix model definition is adopted for the study. It explains disability as not just a medical (health) problem, but a complex phenomenon which stretches to the interactions of the society in which the person lives, placing emphasis on function rather than diagnosis alone ("WHO | International Classification of Functioning, Disability and Health (ICF)" 2018). These disabilities normally affect a person's ability to see, move, learn, communicate, remember, think, hear and relate socially. There are three broad classifications which according to WHO have this dimension, as shown in Table 1.0

DIMENSION	DESCRIPTION
Impairment	This relates to the mental, function or the body's form to function such as blindness, loss of memory and loss of an arm
Activity Limitation	Any hindrance or difficulty in movement, hearing, solving problems and seeing
Participation Restriction	Barriers that prevents you from undertaking your normal daily activities which includes recreational activities, access to health care and preventive services as well as social activities.

Table 1.0: Classification of Disability According to Dimensions (Source: WHO; CDC, 2017)

Diasbility and Barrier free environment in Ghana

As a developing country with a population of about 28 million, it is estimated that 4.2 million (representing 15% – World Health Statistics 2011', 2011; Borg, Larsson and Östergren, 2011) have some form of disability. The Ghana Population and Housing Census (Ghana Statistical Service, 2012) however puts it at 3% of the population. The Ghana Human Development Report by Anand and Ravallion, (1993) and the International Disability and Development Consortium (IDDC), 2018) assert that the three prevalent disability forms are visual impairment, physical disability and emotional/behavioural disabilities as seen in Figure 1.0, which cuts across all three dimensions of disability according to the WHO classifications.

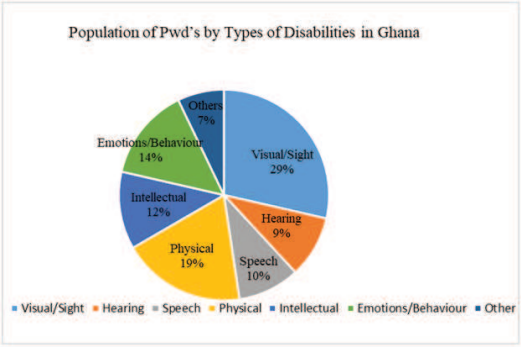

Figure 1.0: Disability Population of Ghana showing the percentages of Various Types and Its Prevalence Source: Extracted from the Ghana Population and Housing Census 2010

Ghana's disabled population is estimated to increase to six million by the year 2025 taking into consideration the growth rate of 2.4% and disability rate of 15%. Critical services and facilities are beyond the reach of the PwDs. An independent survey by the Institute of Demographic Governance (IDEG and SEND GHANA, 2011) indicates that 20% of disabled children are prevented from education; 23% of transport unions lacked written policies on PwDs; 87% and 91% are not aware of disability issues and inadequate measures to enhance disability friendly mobility respectively. The Ghana Disability Act 715 became law in 2016, with the disability code currently undergoing consultations to give clear directions and standards to the law. The Ghana Government Policy on Inclusive Education (GPIE) for example, recognises the right of every individual's access to education irrespective of their gender, race, religion or disability. For Tertiary Institutions, the National Accreditation Board has been given the mandate to ensure that all facilities and buildings and their surroundings of institutions strictly adhere to universal design principles and admissions done without discriminating against PwDs (MOE, 2015; GPIE, 2016)

Smart city concepts and charcateristics

The world is witnessing the digital revolution in urban design for resilience and sustainability in our cities. The smart city concept which is rapidly being embraced by governments and city authorities is premised on the use of intelligent applications for new technologies, whilst incorporating social and environmental capital to transform city life and work (Deakin and Al Waer 2011). In this study, smart city and smart community is used interchangeably and is defined from various perspectives, depending on specific attributes which range from industry to technology and environment (R Giffinger 2007). Now, many cities are adopting the concept to profile themselves as forward looking, prosperous and well endowed. For example, Amsterdam Smart City Initiative uses integrated e-services whilst the Malta Smart City Strategy uses business parks to leverage economic growth (Deakin, Mark.,Al Waer 2012). The European Union (EU) recognises governance as key to building smart cities through collaborative digital environments to boost local competiveness (Curwell et al., 2005, Deakin and Allwinkle, 2007, Paskaleva, 2009). Smart cities are also people based, human and progressive in the processes of the digital technologies, rather than the reliance on hardware technologies themselves. People are the centre and conduit to enhancing good governance, social inclusion and service creation which ultimately will improve the quality of life of the people (Deakin and Allwinkle 2007; Deakin and Al Waer 2011; Deakin, Mark.,Al Waer 2012).

Even though smart is also used to describe a city's use of modern technology in everyday urban life. (Rudolf Giffinger and Strohmayer 2014), there are many who believe that the use of the term smart in describing urban economies is misguided as it tends to dwell mostly on Information Technology (IT). Schaffers, Komninos and Pallot, (2012) and (Gu 2008; Falconer and Mitchell 2012) all expressed concern about what they called fragmented city leading to what Holland (2008) referred to as self-congratulatory tendencies. Various global ranking indices have been used to rank the first ten smart cities with reasons based on the parameters used for the survey. For example whilst the Global Cities and Cities in Motion indices ranked the first three smart cities as New York, London and Paris, Global Metro Monitor ranked Tokyo, New York City and Los Angeles as the smartest cities in the world in the 2017 rankings. (Mora, Bolici, and Deakin 2017) posits two main divergent definitions emerging from the various authors of this concepts namely: 1) the techno centric vision of smart cities emenating from the technology giants such as Cisco and IBM and mostly adopted by cities in the west, and 2) the holistic view often referred to as the humanistic view envisioning the smart city not only as prevalence of high technology but a balanced interplay of human, social, cultural, environmental and economic aspects. The holistic human-centric view has been embraced by many scholars and cities especially in Europe where it emerged. This is evidenced in the scholarly output of authors over the past two decades of smart city research (Mora, Bolici, and Deakin 2017; Rudolf Giffinger and Fertner 2007).

The smart city concept must therefore begin with the people and human capital before IT to transform and improve city living (Deakin and Al Waer 2011). The result will ultimately be finding a solution to the rather splintering urbanism perception as suggested by (Graham, Cornford, and Marvin 1996) where the diverging forces of the digital environment is balanced by the converging forces of human interaction in the physical space (Walters 2011). There is now a rapidly growing sophisticated digital world with information portals and platforms for e-learning, e-governance, community participation and decision making which are spearheading smart cities and communities, but this cannot be effective if vital concepts and tools of physical

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urban design forms the basis of only the electronic discourse (David Walters & Linda Luise Brown 2004; Walters 2011).

The concept of smart to describe a city is very subjective and city or region specific. However, the central theme that runs through all descriptions and definitions of smart city focuses on the use of technology to enhance the work and life of the urban dweller. Thus for a city to be seen as smart, it should exhibit the six broad characteristics as defined and adopted for use by Giffinger et al, (2007) in the ranking of smart cities of medium-sized cities in Europe. These six characteristics are: smart economy, smart people, smart governance, smart mobility, and smart environment and smart living.

Smart people, smart mobility and smart living have direct bearings on inclusive and accessible societies which make the environment very accessible to PwDs in unison with the universal design principles (UD). The seven principles of UD are (1) equitable use, (2) flexibility of use, (3) simple and intuitive, (4) effective use for all, (5) tolerant with minimal error, (6) very efficient with minimal effort from the user, and (7) appropriate in ergonomics (Mueller,2002; 2017). The careful consideration and provision of these principles indicates how accessible the environment is towards PwDs. These characteristics and factors form the operational framework for the assessment of the case studies. (Petrie, 2010; Kose, 2010).

2.2 Case Studies in Singapore and Tel Aviv

Two unique examples of smart city concepts can be seen in the cities of Singapore and Tel Aviv. The two were purposively chosen due to their approach to smart city concepts. Whilst Singapore's smart city concepts is heavily driven by technology, Israel's smart city concept is born out of bottom up approach of human centeredness.Thus these two offer different perspectives explore. Further due to the relatively infant stages of smart city initiatives in Sub Sahara Africa it is imperative that successful countries in this endeavour is used for the case study. Both countries offer innovative ways of using both technology and human –social capital at macro and micro levels of city govenance, mamnagement and living. The smart city initiative in Singapore started form a smart nation vision that was established in 2014. It is a city-nation singling it out as a special case for study. Its smart initiative was pivoted on the three key parameters ICT, networking and data to respond to the urban challenges of ageing population, density and energy sustainability. One in five of its population of 5.5 million is aged 65 and above (Infocomm 2018). Its smart economy is evidenced by strong budgetary surplus recorded (of 1.3% of GDP) for 2017/18 with the government's intention of sharing it amongst its citizens (Scroll.in 2018). Singapore's ambition is to be the world's first true smart nation. Its slogan driving its objective is everyone, everything, everywhere (E3A) and relies on strong smart services – intelligent transport systems. e-governance, and strong government funding to build a smart nation hinged on the five characteristic features of smart cities discussed above.

Figure 2.0: Driverless vehicles on the streets of Singapore (Source: newsweek.com, 2017)

Its major achievements include the integration of different governmental agencies on one platform, ranking it first in delivering e-government; first in smart living in Asia after recording the highest quality of living as reported by Mercer (Mercer Survey 2018), and in smart economy; it is ranked second as the most networked country in the world (Report, Schwab, and Forum 2015).

Singapore has one of the most sophisticated information technology systems to enable smooth flow of traffic and safety on the roads. Smart mobility actions include: motoring which is a common platform for all vehicle owners to access traffic information; the first nation to introduce driverless taxis (Figure 2.0); specific monitoring and advisory systems and vehicle recovery service; 'your speed sign', a smart real time speed check device alerting drivers on speed violations; a parking guidance system to guide drivers to available

parking lots; and a smart application for a bus information system called mytransport.sg which provides real time information for commuters. The nation seeks to be a "car less" nation by 2050 with the injection of huge infrastructure in light rail transport of over 40 billion US dollars. This is to make sure no Singaporean own a vehicle (Aspire, 2017).

Overall the ambition of the nation-city to become a smart nation seems to have a promising future. Special observation will be how their unique system of physical integration yet operating discretely will work together with the utilisation of highly advanced smart systems (Keon et al. 2016). However its challenge has been the over reliance on technology which gives oy a weaker score in many ranking institutions, such as Eden Strategy Institute which scored it 2.0 out of 5 marks in people-centricity (Singapore Business, 2016). The emerging challenges facing the city are managing ageing population, mobility, waste and water supply which must be managed by mitigating limited resources, and operate a public service to generate employment for citizens thereby creating wealth for all (Masero 2016)

The city of Tel Aviv started its smart city project in 2011. Its unique approach of bottom up focusing on residents rather than the infrastructure is a novelty that won it the world's smartest city in 2014. The city has been dubbed as the "non-stop city". The smart model uses a set of decentralised and low-cost processes to build a modular approach and relies on strengths such as focus on residents, low cost, ability to receive feedbacks and liaising with entrepreneurs and the private sector (C. Yin et al. 2015). In the smart economy it is the world' second best ecosystem with 70 start-ups and 1000 entrepreneurs in 2014 (Kim et al. 2016).

Figure 3.0: An interactive mobile application interface for all citizens called DIGI-TEL in Tel-Aviv. (Source: www.parismatch.com, 2018)

The core objective is to improve local resources and improve local resident's engagement in governance. This has created more trust between the municipality and its citizens. Through citizen oriented innovations, local solutions are found to address specific localised problems as seen in Figure 2.0 (Batty 2013; C. Yin et al. 2015; Shapiro 2006). The city's perspective on smart city is in agreement with Hollands (Hollands and Hollands 2008) and Angelidou (2015) as a process of driving technology into the fabric of the city, making it an ongoing process with the human being as the conduit to achieve effective results. Tel Aviv's smart people, smart living, smart environment and smart mobility hinge on a connected set of information sources and systems extensively used in the digital media, often operated through citizen interactions on mobile applications, social media and municipal websites as shown in Figures 3.0 and 4.0.

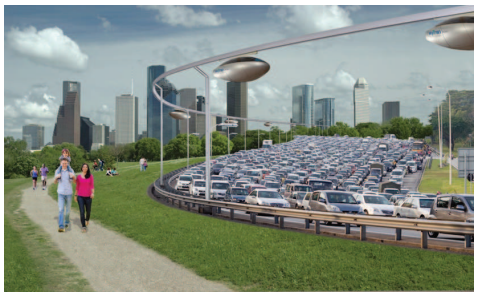

Figure 4.0 Tel Aviv's Sky Taxis seen as optimal alternative to traffic in Tel Aviv (Source: www.parismatch.com, 2018)

Key lessons to be drawn from its approach are: 1) smart city projects must address a very specific pressing need of the society; 2) the power of individuals are unleashed through local competition initiatives; 3) smart

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initiatives can be started with a small budget without necessarily relying on government for huge funding; 4) the city's governance is smartly micro-managed through the use of small scale projects to control the city's budget; and 5) there is active participation through active participation of all. The use of technology has allowed PwDs to communicate their ideas and proposals to the city authorities through the various platforms provided. One challenge of the city's approach towards smart is how to converge all these different operating IT platforms.

Conversely, Singapore's smart initiative has been recommended for sustainable smart cities with a bias towards ICT (Paskaleva 2009; Townsend 2013) which synchronises with the nation's way of life of the people and more especially their system of governance. Thus cities with a low budget or limited funding will seek the approach adopted by Tel Aviv as it creates a well balanced approach between converging forces of human interaction and the sophisticated digital world. (Walters 2011; David Walters & Linda Luise Brown 2004)

2.3 Case study: Smart University Initiatives

A summary of the results of the case studies carried out at the University of Nottingham, UK, and the University of Johannesburg, South Africa is presented in Table 2.0. They were chosen based on their location and specific smart initiatives undertaken. Their inititives were evaluated at against the six characteristics of smart city concepts, with a seventh characteristic focusing on smart accessibility initiatives.

Name Of University/ Smart Features	University of Nottingham, UK, China, Malaysia	University of Johannesburg, Gauteng, South Africa
Brief Description	Officially formed in 1948, it is home to over 44,000 students in four campuses in three countries	Formed in 2005 with four campuses through the merging of 3 universities. Has over 50,000 students
Smart Economy	1. It is seen as one of the highly ranked university both locally and international being among the top 1% of all universities globally. 2. Has 30% of student population as international students 3. The university generates averagely £677m and £1.1bn for the city and the nation respectively. 4. Job creation for the city and nation are 14,000 and 18,000 respectively.	1. Ranked among 2.3% university worldwide and 5th in S.A. It is the only African university in the consortium of 28-research intensive universities in the world. 2. There is a close collaboration between the city and the university of Johannesburg in common projects of interest 3. Public private partnerships to bring in funding for developments 4. Establishment of offshoot companies to commercialise its research outputs
Smart Governance/ Administration	1 .The use of a multipurpose smart card for a host of services such as building access, identification, online services etc. 2. The up research excellence framework ranks it 8th amongst the top ten universities 3. Over hundred of students organisations for socio cultural interactions and wellbeing	1. Online platform for course delivery materials, announcements and student attendance at lectures. Again this is used for library services 2. Has students representatives in all campuses as well as the main students representative council elected by the students
Smart Mobility	1. Use of electric vehicles as an environmentally friendly energy 2. Free bikes and maintenance 3. Free hopper bus system shuttling within and between campuses	1. A variety of transportation options- free busses 2. The use of bicycles are in the minority 3. There is lack of an effective public transport policy
Smart People	1. A vast majority of the residents on campus have access to smart devices to assist in their daily 2. The campus host a multiplicity of residents- under graduates, masters, PhD, post docs as well as professors and visiting researchers	1. 80% of population has access to a smart device 2. Several interactive platforms for interactions 3. Online platforms for academics and administration. 4. Has campus radio stations and students newspapers to broadcast information to and from city
Smart Living	1. Navigational maps and 2. Access to materials and other services within reach and comfort of students and staff 3. Green roof insulation and heat recovery ventilation systems 4. Lighting sensors, photovoltaic cells and Biomass boiler 5. Sports and recreational facilities for healthy lifestyles	1. Free Wi-Fi services 2. Accessing materials online and participating in coursework 3. Access to housing options both within and outside campus. 4. Has numerous sporting venues for various sports, and an arts centre for cultural diversity 5. Accommodation options exist in 35 residences in all four campuses. 6. Off-campus accredited Privately owned accommodation are within 2 km reach of campus with transportation provided
Smart Environment and sustainability	1. Efficient and responsive and sustainable campus 2. Waste bin monitoring and collection by weight system 3. Lots of water bodies with variety of aquatic and wildlife 4. Storms water attenuation 5. Building cooling and active passive ventilation systems	1. Smart water metres, heat pumps and water heaters installed in facilities 2. Energy efficiency through retrofitting 3. Plans in advance to install photovoltaic cells at rooftops, and rain water harvesting on rooftops. 4. Garbage bins has been placed for easy separation and recycling

		5. A clean form of energy called fuel cell Rubicon is being installed for efficient energy system for the city in future.
Barrier free /Accessibility Provisions	1. Way finding systems are available through assistive devices. 2. Accessible floor plans showing essential spaces and locations such as toilets, entrances, ramps automatic doors, lifts etc. 3. Accessible free transport services for PwD's with personnel support 4. Disability support Centre called access centre to counsel diagnose and support in learning and living comfortably 5. Disability bursaries to offer assistance to PwDs 6. Accessible learning materials and concessions through coursework extensions, examination rescheduling, recorded lectures and training assistance.	1. There is a disability centre to offer various forms of support to PwD's 2. Confidential information and assistance to PwD's in living coursework and examinations at PsyCAD offices 3. Provision of assistive devices at very affordable cost 4. Accessible transport services for PwD's. 5. Reasonable accommodation for PwDs.

3 METHODOLOGY AND STUDY PROFILE

3.1 Methodology

The study was conducted at the Kwame Nkrumah University Science and Technology (KNUST) in Kumasi in the Ashanti Region of Ghana. The study is underpinned by the constructivist's worldview with an adoption of the mix method in a QUAL-quant ratio of 60:40 as it sought to investigate a phenomenon in a real life context (R. K. Yin 2009; Phelan 2011). The qualitative aspect of the study involved the case study of the KNUST and Kumasi city whilst the quantitative aspects dealt with secondary data from precedent studies of Singapore and Tel Aviv as smart cities, as well as the Universities of Nottingham and Johannesburg by virtue of their smart initiative strategies. Data was gathered through a structured questionnaire survey and interviews in accordance with existing theories and findings from literature. A purposive sampling method was used to gather this data from a cross section of people attending a five-week summer workshop for students, lecturers and workers in geographic information systems on KNUST Campus in June/July 2017. They were asked to identify and rank barriers that impede accessibility for all on campus, as well as their perception and ranking of smart principles ideas on campus. In all 125 people were sampled.

A campus audit was also completed through physical measurements, updating of existing documentation and observation. Data collected was analysed through SPSS and Excel in table and graphical representations of results. Ranking was done using a score of 1 to 5 with 1= lowest and 5= highest to measure the respondents perception about factors on smart concepts. In calculating the scores for the variables in each category, weights were given to the ranking (1= -2; 2= -1; 3= 0.5; 4= 1; and 5 = 2). The sum of average scores of respondents for each category were summed up to obtain an overall ranking score.

3.2 Profile of Study Area

The study area, Kwame Nkrumah University Of Science and Technology lies in the heart of Kumasi, the most populous city in Ghana, with 2.2million people and expected to reach 3.4 million by 2025 (Earth Institute/ Columbia University 2018). The city is well endowed with cultural heritage and often known as the Garden City of Ghana due to its ecological landscape. As the capital of the great Ashanti Kingdom, it is located in the Oforikrom Sub Metropolitan area. The university campus covers an area of about eight square miles which contains 41,333 students from over 32 different nationalities offering various academic disciplines. The University is well-known for its strides in science and technology innovations for the country since independence (KNUST, 2018). Established about sixty years ago, it boasts of a serene greenery of undulating landscape and forest groves blending beautifully with the subtle but expressive architectural forms from different eras. In addition, it is resident to more than 3,000 academic and administrative staff. Major functional zones (Figure 5.0) include: the academic area, commercial areas, hospital area, residential areas, and play areas, open spaces and parks, forest reserve and botanical

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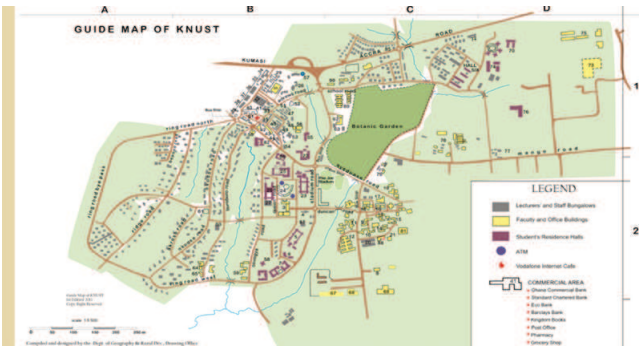

Figure 5.0: Functional and Built Up Areas of KNUST (Source: Department Of Geography, KNUST, 2017).

garden, maintenance and security, civic areas, religious areas, utility and recreation. The campus provides services to over 55,000 people of all ages ranging from educational, health, recreational, commercial, religious and residential.

It is the greenest zone on the city map and a major commercial hub for surrounding towns and those avoiding transactions in the undue traffic towards the central business district. The campus has good infrastructure facilities with over 90% of all roads tarred and in good condition and major road spines having pedestrian walkways and well lit street lights boosting the level of security and safety on campus for users (see Figure 6.0).

Figure 6.0: Section of Campus Showing Infrastructure Installations at Major Crossroads (Source: Field survey, 2017)

Finally recent installations of CCTV at major crossroads on campus add to the security of the users. Free Shuttle busses and taxi services are available with bus/rest stops at vantage points.Uber services also augment transport services.

4 RESULTS AND DISCUSSION

4.1 Charcteristics of Sample Population

A total of 125 people were sampled from a summer workshop on the use of geographic information systems for students, lecturers and the general public. The sample were purposively chosen for this exploratory work as it presented the opportunity of having a cross mix of population sample to give a true reflection of the campus. Respondents were voluntarily asked to participate in the survey. Out of the total sample questionnaire distributed, 101 responded and 100 were validated giving a respondent rate of 80%. The successful respondents comprised 85% students, 5% lecturers and 10% from other occupations.

4.2 Disability and perceived barriers on campus

Respondents were asked to indicate any difficulty with respect to their day to day tasks under the various types of disability. As shown in the Figure 7.0, the three main disability types found among the respondents in order of prevalence were memory, speech and sight. Memory for example amounted to 27% indicating some form of difficulty either little or severe. This is in contrast with the national disability statistics which gives the three prevalent form of disability as seeing, hearing and physical disabilities.

Multiple forms of disability were also recorded with 7% indicating more than one form of disability. Further, 54% of respondents had realised their disability recently; 30% had it years back whilst 16% have had it since childbirth. An indication of a growing phenomenon of recent cases of diagnosis needs further attention to find out the causes.

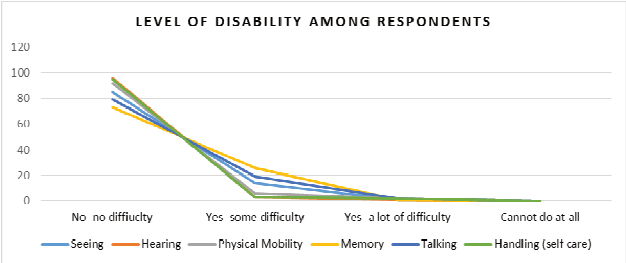

Figure 7.0: Levels of Disability among Respondents (Source: authors' construct, 2018)

The respondents indicated that three barriers prevalent on campus are: physical barriers (77%), information and communication (72%), and technology (41%). When asked further to indicate the specific barriers, the results in order of magnitude were: absence of lifts (71%), absence of legible directional maps (53%), lack of adjustable seating (47%), lack of automated doors and lack of protected walkways, lack of automated entrances, lack of automated lighting, absence of audible sensors (23%), lack of e-health and e-banking(10%).

Respondents rated the campus performance on barrier free environment as 20% good, 30% fair, 43% poor and 7% very poor. Meaning 50% gave the university below average in dealing with issues of disability. Information and Communication Technology (ICT), legislation and enforcement, and sensitisation were mentioned as factors that will speed up a barrier free campus. A majority of the respondents (52%) believed that ICT holds the key to ensuring an environment free of barriers. When asked to make suggestions for future improvements the following ten were ranked in order of most suggested: 1) directional maps; 2) smart mobility; 3) adjustable furniture; 4) bbstacle free and guarded walkways; 5) accessing e-learning options; 6) Specialised spaces; 7) audible sensors; 8) lifts in buildings; 9) signage; and 10) coloir contrast in buildings. The results support the existing provisions visually observed on the university campus as most the built up places lacking provisions to enhance accessibility of the disabled.

4.3 Mobile Phone Usage And Data Accessibility

Respondentds were asked about the general usage of the mobile phones on campus. The results indicated that every one had a mobile phone with 90% using a smart mobile phone or tablet. Pre-paid data usage, free WIFI data were the two main sources of data with 60% and 40% respectively. When asked further how reliable the mobile service providers were in terms of data respondents scored 55% for MTN, 30% for Vodafone, 10% for Airtel-Tigo, and 5% for other networks. Information/social media, mapping and navigation, banking and mobile money services were the three main uses of data by respondents. The results reflect earlier studies conducted (as seen in Figure 8.0) by Marful et al, 2018, which showed that information and research, mapping and navigation, mobile banking and mobile money, health and fitness assistant and way finding are the other important usages of mobile phone data.

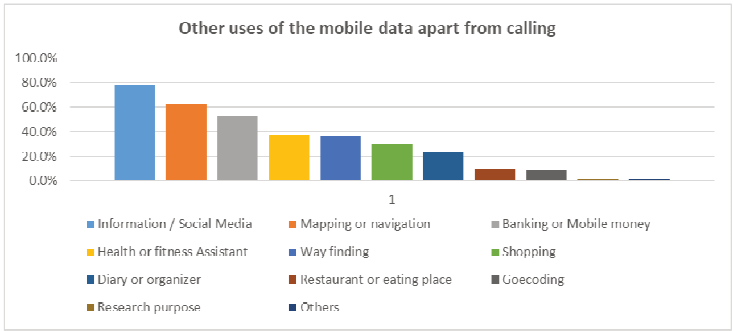

Figure 8.0: A Graphical representation of respondents other usage of mobile phone data (Source: Marful et al, 2018).

4.4 Perception And Performance On Smart City Initiatives

The majority of the respondents (78%) indicated their knowledge of the smart city concept from four different sources: literature (31.4%), social media (28.6%), course study (22.9%), and conference/workshops (17.1%). When asked of their opinion on whether it is a threat or an opportunity for national development 96% agreed it was an opportunity. On the issue of its urgency of the merging concept in Ghana, 50% agreed it was urgent or very urgent whilst 19% disagreed. However 31% were indecisive.

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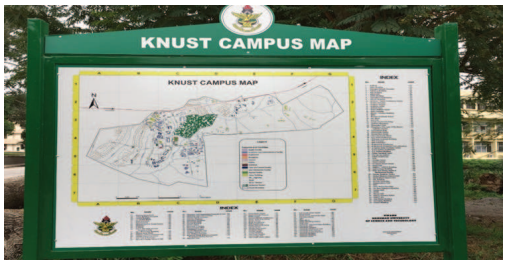

Figure 9.0: KNUST Map at Vantage Points on Campus showing Location of Various Facilities on Campus (Source: KNUST, 2017).

Figures 7.0 and 8.0 shows some of the initiatives on the university campus to enhance safety and accessibility of all people who visit the campus. Though most agreed that the concept was good, 59% thought it was expensive and 33% thought it was not so expensive. However 8% thought there was no difference between what is being practiced currently and the smart city concept.

Figure 10.0: A view of main arterial road from the teaching faculties towards central administration to the showing cctv cameras, solar street lighting and pedestrianized routes (Source: authors construct, 2017).

Smart city performance

In an effort to investigate the perception of respondents on the current performance of the university against the measured variables in a smart city, they were asked to rank each of the variables from 1 (lowest) to 5 (highest) according to what they believed was the performance. The results as shown in figure 7.0 indicate the results of various perception of each variable.

In the smart economy category, innovative spirit, entrepreneurship and international image were the strongest indicators whilst flexibility of labor market scored the lowest. This may be attributed to specialised forms of labour at the university campus leaving little room for diversity, but the strong entrepreneurship and innovative spirit is sufficient a catalyst to spur the university towards smart economic initiatives. Variables under smart people received the most positives giving credence to the caliber of people found on average in the university with respect to level of qualification, creativity and cosmopolitanism. Smart governance and smart environment variables received lower scores making the two factors the weak links to attaining a smarter campus. In this aspect environmental pollution and political pluralism should be given much attention as it scored the lowest among their categories.

Under smart mobility, a strong score for ICT is indicative of the available infrastructure and the potential of using this to spearhead smart campus concept. This can be used to enhance city and national accessibility as well as provide an easy way of finding systems for inclusive environments. The university boasts a web portal (aim) which at present offers services such as payments of fees and other bills, examination and tutor related interactions, registration and course materials amongst others for students, which can be developed further to provide needed information, communication and interactive tools for better mobility. Tourist attraction and cultural facilities were the variables that fell short of respondents expectations whilst health conditions, education and housing received stronger scores. Tourism holds a huge potential with the unique location and attraction of the serene environment of the campus.

Table 4.0 shows the average scores for each characteristic factor of smart city as perceived by the respondents. On scale of 0 to 100, smart people scored the highest (73.20). This can be a reflection of the higher academic degrees, the socio-ethnic mix, as well as the diverse learning oportunities available to all. The free bus shuttle services on campus gave smart mobility the second highest score of 68.60 as it has greatly enhanced movement of people on campus. Smart governance had the lowest satisfactory score of 56.10 perhaps an indication of the rigorous and bureaucratic system of administration at the university. The

administration of the university makes the majority of the decisions at the top of the hierarchy, giving little student participation in govenance.

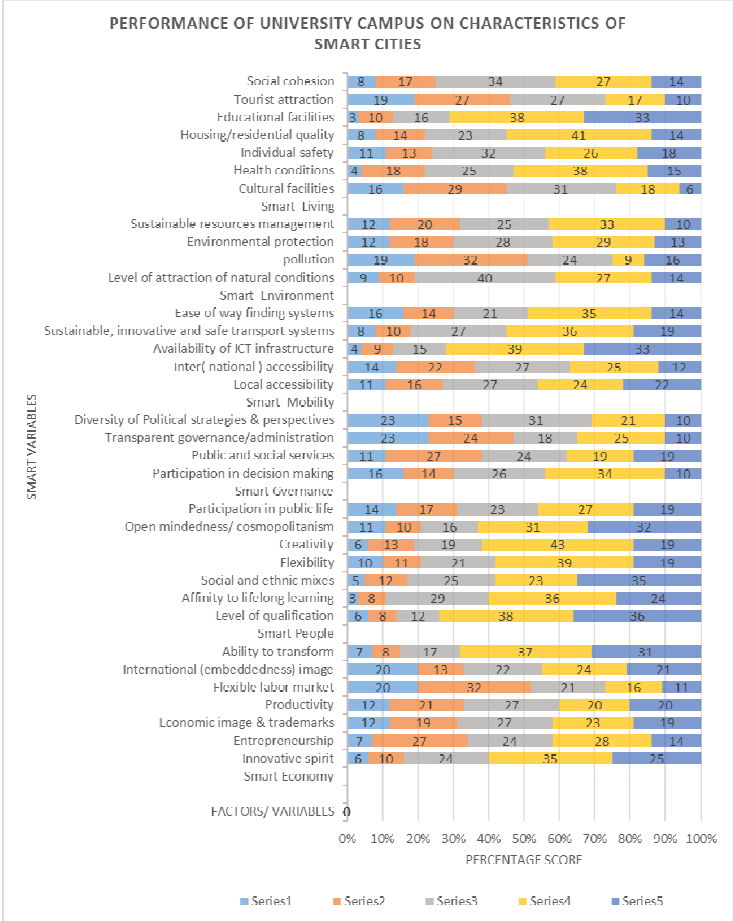

Figure 9.0: Performance of the University Campus on Smart City Concepts: Series 1, 2,3,4,5 representing lowest, lower, fair, high and highest perceived performance respectively. (Source: authors construct, 2018).

ITEM	FACTORS	MEAN SCORE
1	Smart Economy	63.70
2	Smart People	73.20
3	Smart Governance	56.10
4	Smart Mobility	68.60
5	Smart Environment	62.20
6	Smart Living	65.40
Overall Score		64.80

Table 4.0: Overall Score of the university Campus on smart city concepts (Source: authors construct, 2018).

However the university campus performance on the overall scale was 64.80 which was above average performance. This means that respondents showed some level of satisfaction but had issues with certain features, such as pollution and environmental protection of, openess in govenance, restricted accessibility of the built environment, lack of alternative transport systems amongst others which need to be tackled in order to enhance the perception of residents' of living and working on campus environments that are based on principles of smart cities and are barrier free.

5 CONCLUSION AND RECOMMENDATIONS

The main purpose of this study was to explore the concept of barrier free as a catalyst in creating smart communities in Sub-Saharan Africa. KNUST was used as a case study to assess the effectiveness of barrier free principles in enhancing smart environments. The information and analysis presented dealt with students, academic and non-academic staff. Findings are applicable in Ghana and other developing countries with similar characteristics.

Based on this, the research offers the following conclusions and recommendations:

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- Three major forms of disability of people living on the KNUST campus are physical, sensory and cognitive impairments; such persons find it difficult to perform everyday tasks due to the presence of various barriers.
- The majority of these PwDs agree and welcome the use of smart and assisting technologies in removing barriers; the smart mobile phone technology has almost 96% accessibility on campus. Whilst most agree with the urgency of barrier free living and its considerable benefits for the country's speedy development, there were some concerns about the high cost of its implementation.
- The overall performance of the campus as regards the characteristic factors of smart city concepts was average, with perceived strengths in smart people and smart mobility, whilst its weak links were the environment and governance.

On the basis of the conclusions, this study makes the following recommendations:

(1) The university must take a critical look at investigating the backgrounds of students and staff to ascertain the actual levels of disability to implement specific policies that promote an inclusive environment for all

(2) Further research should be conducted to address the needs of the Ghanaian Universities as smart campuss that will insure the benefit of all, taking into consideration cost and resources, and

(3) A comprehensive strategy to make universities smart through barrier free innititaives must be developed and rolled out nationwide. The university campus is best placed to serve as an innovation hub and technological drive to initiate such actions aimed eventually at barrier free environments nationwide.

These findings do not necessarily reflect the perception of the entire university population due to the size of the sample population but give a fair idea of the thoughts and perceptions of residents on the campus. This is an ongoing PhD research on barrier free and smart city concepts by the authors at the Kwame Nkrumah University Of Science And Technology, Kumasi-Ghana.

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