RESEARCH ARTICLE

Appraisal of the drivers of smart city development in South Africa

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Abstract

The quest for smart cities and development has been on the increase among infrastructural development stakeholders, including clients, government agencies responsible for the management of infrastructures, construction professionals, sponsors, and financiers of these projects. However, studies around the world have shown that less attention is being paid by these stakeholders to various indices and measures of smart cities. These measures and indices, known as drivers, are smart environment, smart economy, smart people, smart governance, smart mobility, and smart living. Using these drivers and their indicators, a multiple-choice questionnaire was designed in line with existing and relevant literature materials in the subject area. These questionnaires were administered on construction professionals with relevant and adequate knowledge of smart construction. Smart environment was found to be a major driver of a smart city while smart people, smart governance and smart living are also key to the achievement of the goals and objectives of the concept. The developed key smart city drivers are a workable, adaptable and efficient city design mechanism and it will be useful for city planners, statutory agencies as well other stakeholders in the development of smart cities.

Keywords:

Information technology, smart city, smart technology, social cohesion, sustainable construction

Introduction

A city has been described as a highly organised community, with a substantial amount of development and innovation needed for the sustainability of a nation's economy (Amer, 2014; Bawa *et al.*, 2016; Villa and Mitchell, 2009). Govender (2018) further described cities as "businesses" as they can generate income for the government through taxes. Furthermore, Kumar et al. (2018) described cities as a large environment which provides the people dwelling in it with lots of opportunities to advance in life and services needed for comfort. However, despite the high importance of this type of settlement to every nation, the nature of most cities in developing countries have been described as "a far cry" from what a city should be (Aghimien *et al.*, 2019). Rapid urbanisation has left most cities with lack of needed amenities as severe pressure is placed on meagre available resources within these cities, because too many people depend on little infrastructure provisions (Ogundare and Ogunbodede, 2014). Respite is not in sight in terms of this rapid urbanisation, as it is projected that by the year 2050, over half of Africa's population will be living in cities (United Nations, 2017). Although not the worse among developing countries, especially in Africa, South Africa suffers this same fate. Most cities in South Africa are described as transitioning cities because they have a high urbanisation rate (Deloitte, 2014). The resultant effect of this is high pollution and poor utility delivery for dwellers (Alfano, Amitrano and Bifulco, 2014). Thus, considering the important nature of cities to socio-economic development cum the continuous growth in population and rapid urbanisation being experienced in most countries, the call for cities to be 'smart' has become crucial.

Defining a smart city and describing the requirement for attaining one has been a focal point for most researchers in recent times (Das 2012; Hollands, 2008). Although achieving consensus on the definition has not been easy (Myeong, Jung and Lee, 2018), Giffinger et al. (2007) and Sikora-Fernandez (2018) opined that several characteristics exist that gives pointers to a smart city. In the view of Silver *et al.* (2018), smart cities are connected cities. Gceza (2018) and Moshtaq (2018) described it as safe cities in terms of humans and cyberspace. Govender (2018) noted that a smart city is a data-driven city. Based on these descriptions, Aghimien *et al.* (2019) concluded that smart cities are interconnected through the use of Information and Communication Technology (ICT), provides adequate security for the physical and information space of its citizens, and uses the data generated within the city to make informed decisions that will better the lives of the people living in it. In the view of Macke *et al.* (2018) smart cities are a complex ecosystem with the ability to improve the way of living of their inhabitants, through a network of people, processes and data. Based on these definitions, it can be deduced that the attainment of smart cities is dependent on certain factors that are needed to propel its engine. These factors are 'Smart City Drivers'.

In South Africa, several measures are being considered to propel city smartness. By adopting diverse digital technologies (DTs), ICTs and broadband connectivity, it is believed that a smart city that adopts intelligent services in achieving innovative environments can be achieved (South African Local Government Association, SALGA, 2015; Oke, Aigbavboa and Cane, 2018b). Das (2012) has earlier noted that through proper adoption of DTs needed

for the attainment of smart cities, the government will be able to effectively link different city components with the needed infrastructures. Through this, the standard of living as well as the social and economic wellbeing of the dwellers can be improved. Unfortunately, despite these submissions, the idea of a smart city in the country is still more of a dream than a reality. The study of Giffinger *et al*. (2007) has propounded the key drivers for the attainment of smart cities. In a bid to promote smart city attainment, other studies have explored these drivers holistically (Lee, Phaal and Lee, 2013; Lombardi *et al*., 2012; Neirotti *et al*., 2014). However, a literature search on the drivers of smart city in the South African context came back negative. This implies the need to fill a knowledge gap on the drivers of smart city attainment in South Africa and to provide a defined roadmap for the government to follow in their quest for a smart South African city. To this end, this study sets out to assess the drivers of smart city development as a roadmap for the transformation of cities in South Africa, using Gauteng province as a point of reference.

Review of Smart Cities Drivers

Studies have shown that although smart city concept has existed since the 1990s, it is only gaining popularity among academics and professionals in recent times because of the need to improve the quality of life of city dwellers (Lombardi *et al*., 2012; Neirotti *et al*., 2014; Peprah, Amponsah and Oduro, 2019). This recent popularity is not unconnected with the need for sustainable development in countries all over the world (Datta, 2015), and the increasing advancement in ICT and DTsthat have evolved in recent times (Aghimien *et al*., 2019). Dawe and Paradice (2016) earlier noted that a smart city uses ICT development to attain and improve sustainability, economic development of a country, and the quality of life of the citizens. Kumar *et al*. (2018) noted that smart cities adopt the use of ICT and Internet of Things (IoT) in city development, specifically in the aspect of "government functionality, city operations, services deliveries, and intelligent analytics to soptimise services, production, and usability".

Giffinger et al. (2007) observed that the concept of a smart city is built upon six essential components. Although the study opined that these six components should serve as the bases for defining and achieving city smartness, some studies have adopted these six components in their holistic forms (Ghosal and Halder, 2018; Lee, Phaal and Lee, 2013; Lombardi et al., 2012; Neirotti et al., 2014) while others have gone ahead to expand these components (Frost and Sullivan, 2012; Myeong, Jung and Lee, 2018; Oke, Aigbavboa and Cane, 2018b). These six components are smart environment, smart economy, smart people, smart governance, smart mobility, and smart living.

SMART ENVIRONMENT

Das (2012) has earlier noted that to attain a smart environment, there is the need to put in place resource management plans. This is necessary to protect and preserve the natural environment and at the same time, conserve non-renewable resources within the area. Giffinger *et al*. (2007) hinted on the need for proper sustainable resource management and protection of the environment. Lombardi *et al*. (2012) also linked the smart environment to efficiency and sustainability of resources. Ghosal and Halder (2018) described it as the proper management of energy, water and waste. This is one crucial aspect also being championed in South Africa with the National Development plan of 2030 which is geared towards ensuring a sustainable environment with an adequate supply of needed

infrastructures and wise consumption of energy (National Planning Commission (NPC), 2030). To achieve a smart environment, Bawa *et al.*, (2016) noted the need to properly control and manage the city's utility systems. Conservative use of electricity, water and other non-renewable resources, as well as the inclusive use of ICT networks, IoT, and smart meters, can also help promote a smart environment (SALGA, 2015; Washburn and Sindhu 2010). The implementation of relevant policies and strategies to reduce pollution of urban centres is also essential. Only through this, can the diseases being suffered by urban citizens because of environmental pollution, be reduced (Das, 2012; European Chronic Disease Alliance, 2015). However, the attainment of a smart environment does not only depend on the adoption of ICT, IoT and DTs or even putting policies in place. Citizens also need to be pro-active and improve their habits to conform to the created policies (Das, 2012). There is also the need to transform existing public spaces into green public spaces to encourage awareness of their natural environment (European Union, 2014). This is accompanied by the need to promote waste reduction and the use of renewable and recyclable materials (Bawa et al., 2016).

SMART ECONOMY

According to Angelidou (2015), a competitive city depends largely on the knowledge capital of its urban population. This was further described as a "knowledge economy" which encourages knowledge-intensive activities rather than labour-intensive activities which are the popular approach in most cities. To this end, the development of entrepreneurs is encouraged within the city economy (Giffinger *et al.*, 2007). Providing a policy that encourages entrepreneurship at a domestic level, provincial and local level will help boost the development of both the formal and informal sectors as creative people can help the government grow the economy of the country (Peberdy and Götz, 2016). Bawa et al. (2016) observed that a smart economy includes having new income generation models, being the largest economic centre, competitive in pricing and having both global and local investments. This is believed to be achieved through adequate skill development to boost knowledge capital, encouraging innovation and entrepreneurship as well as having trade centres. Alfano, Amitrano and Bifulco (2014) have earlier noted that adopting systems that will promote increased external funding and the expansion of local businesses is essential for a smart economy. Ghosal and Halder, (2018) further noted that a smart economy is driven by an innovative spirit, employment and e-business within the city.

SMART PEOPLE

Giffinger *et al.* (2007) described smart people as the social and human capital aspect of attaining smart city. This includes participation in public life, an increase in education and creativity and flexibility of human activities, which can be achieved through proper use of smartphones and applications, good internet connectivity and access to information. The World Bank (2007) has noted the power of knowledge to be a crucial component of local growth due to its ability to create a competitive advantage for individuals, organisations, or city. This, therefore, creates an avenue to prompt both global and local financiers to invest in the urban district. In South Africa, the NPC (2012) noted that for improved unification of urban districts and citizens; change, update and allowance for increased basic service supplies and development of areas set aside for civic use is necessary. This is to attain a more unified and equitable civilisation and reflect a socially cohesive society.

SMART GOVERNANCE

Smart governance involves having a transparent government that has sound political strategies and considers its citizen's viewpoints in decision making (Alfano, Amitrano and Bifulco, 2014; Giffinger et al., 2007). Gcaza (2018) opined that smart governance deals with citizens' engagement, government transparency, digitalisation of government's records and open data. Giffinger *et al*. (2007) have noted that this can be achieved using open data portals and e-service delivery of government activities. However, Ruhlandt (2018) have observed that the major problem facing the transformation of most cities from being ordinary cities to being smart cities is the lack of appropriate governance arrangements. Therefore, for a smart city to be attained smart governance must be given thorough consideration. Focus on innovative ways of e-governance can go a long way in achieving this feat (Hollands, 2008). Bawa *et al.* (2016) see this aspect as ICT enabled governance, and if the government is determined to achieve smart cities within its urban centres, it must be ready to first integrate ICT platforms into various aspects of key governments functionalities. This integration of ICT into government functions will ease real-time communication between the government and its citizens, thereby creating a platform with the cognitive capability to improve political awareness within the area (Colldahl, Frey and Kelemen, 2013). Ghosal and Halder, (2018) further emphasised that the aspect of smart governance includes e-democracy, public e-service delivery, transparency and accountability of government as well as efficient administration within the city.

SMART MOBILITY

Giffinger *et al*. (2007) described smart mobility as the infusion of ICT to transport that brings about local and international accessibility, ICT infrastructure availability, as well as sustainable, safe and innovative system of transportation within urban centres. According to Deloitte (2014) encouraging public transport system and reducing the number of private cars using city roads will most ultimately reduce the emission of greenhouse gases and at the same time alleviate the enormous traffic congestion evident in most cities. Studies have shown that reducing air and noise pollution, reducing traffic congestion, improving the safety of citizens, improving the speed of transportation while at the same time reducing its associated cost are some of the key objectives of smart mobility (Bencardino and Greco, 2014; Giffinger *et al.*, 2007; Peprah, Amponsah and Oduro, 2019). Bawa et al. (2016) went further to state that smart mobility involves having an intelligent transport system through effective ICT infrastructure. It also involves being able to capture real-time data and analyse them using smart hardware such as sensors and cameras, and smart software and tools such as mobile applications.

SMART LIVING

The concept of a smart city revolves around creating a better living condition for the city's citizens (Aghimien *et al.*, 2019; Macke *et al.*, 2018). Smart living, therefore, places focus on the wellbeing and quality of life of individuals within urban areas. This is driven by innovative education and implementing skills development programmes that empower small, micro and medium enterprises. It also involves improving health care services through diverse means such as e-Health project (SALGA, 2015; Oke, Aigbavboa and Ngema, 2017) and improving the safety of individuals through the use of surveillance cameras throughout the city (Colldahl, Frey and Kelemen, 2013). Giffinger *et al.* (2007) described smart living as an embodiment of proper educational and cultural facilities, proper health conditions, safety, improved housing

quality, tourist attraction and social cohesion within a city. Ghosal and Halder (2018) noted that smart living involves protecting cultural values and providing happiness for individuals in the city. Hence, Aghimien *et al*. (2019) described a smart city as a safe and happy city. A similar notion was held by Alfano, Amitrano and Bifulco (2014) that preserving cultures and the development of modernised social facilities is a key attribute of smart living.

Research methodology

This study assessed the drivers of smart city development in South Africa. This was achieved through a quantitative survey conducted using a questionnaire. The questionnaire was adopted due to its simplicity and ability to cover a wider range of audience within a short period (Tan, 2011). Also, it is among the most widely used social research techniques (Blaxter, Hughes and Tight, 2001). The survey was conducted among professionals with relevant and adequate knowledge of smart construction. These professionals include Town Planners, Contracts Managers, Project Managers, Architects, Quantity Surveyors, Civil Engineers, Electrical Engineers and Data technicians (IT) that are currently practising in the construction industry within the Gauteng province of South Africa. Due to the difficulty in determining the exact number of professionals working in areas related to smartization of cities within the study area, having a defined sample size was practically impossible. Thus, the study adopted a snowball approach wherein 32 professionals were identified and sampled accordingly. Heckathorn (2011) noted that snowball sampling assumes that a link exists between one sample and others in the same targeted population. This creates a platform for referrals to be made within a circle of acquaintance. A similar approach was adopted in the study of Rahman (2014). Despite adopting the snowball process, strict selection guidelines were adopted, and respondents were chosen for the study based on a considerable number of years of working experience within the construction industry (at least five years working experience), and current involvement in a construction project within the study area.

The study recognises the possibility of selection bias among the respondents since on professionals working within areas of transforming existing cities in South Africa into technology-savvy hub were selected for the study. This is a common type of bias within most survey studies (Šimundić, 2013; Smith and Noble, 2014), and Holmes (2004) has warned of the occurrence of such bias when a sample adopted is small as in the case of this current study. This type of bias is mostly curtailed using random sampling approach (Daly, Bourke and McGilvray, 1991; Šimundić, 2013; Smith and Noble, 2014), however, this is not practically possible for this study as the total population of professionals involved in smart city construction was difficult to determine from the onset of the study. While this is one of the major limitations to the findings of the study, the validity of the result was ensured by using unambiguous questions and well-defined terms to ensure a clear understanding of the research questions by the respondents as recommended by Yousuf (2007). The reliability was also tested using appropriate statistical tools, as observed by Sarantakos (2005). The questionnaire used was close-ended in nature and were self-administered. Two sections were used in the questionnaire to harness information from the respondents. The first section gathered information on the background of the respondents, while the second harnessed information on the drivers of smart city development in South Africa. Variables used in the second section were gathered from the review of existing literature on the drivers for smart city development. Respondents were presented with these variables and were asked to rate them based on their level of significance to the attainment of smart cities in the country. A 5-point Likert scale was adopted with 5 being very high, 4 high, 3 average, 2 low and 1 very low.

In analysing the data gathered, 3 distinct steps were followed. Firstly, the reliability of the research instrument was determined using Cronbach alpha test. This test is used to measure the reliability of a questionnaire between each field and the mean of the entire fields (Santos, 1999). Cronbach alpha gives an alpha value is between 0 and 1, and the higher the value, the more reliable the questionnaire (Moser and Kalton, 1999). A Cronbach's alpha value of 0.940 was derived for all the assessed drivers of smart city development and this shows that the instrument is highly reliable. Aside from the reliability test, the normality of the data gathered was also assessed using the Shapiro-Wilk test. The test revealed that the data gathered were not normally distributed as a p-value of 0.000 was derived for all assessed drivers. This is less than the 0.05 threshold for normally distributed data, hence only a non-parametric test can be conducted. The second step was to rank the various drivers based on their level of severity as indicated by the respondents using their mean item score (MIS). The premise of decision for the ranking is that the factor with the highest MIS is ranked 1st and others in such subsequent descending order. Chan, Darko and Ameyaw (2017) have earlier noted that the MIS is one of the most common descriptive analyses in construction research and it has proven to be an effective method in identifying key factors among several individual factors. Since respondents were sampled from a different profession, there is the tendency for some disparity in the way they rank these assessed drivers. This assumption necessitated the third step of data analysis which is to identify the specific drivers with a significant disagreement between respondents. This was done using Kruskal-Wallis H Test which is a non-parametric test used in ascertaining the significant difference in the view of three or more group of respondents. Kruskal-Wallis H Test gives a chi-square value and a significant p-value, and when the derived p-value is lower than the predetermined significance value of 0.05, it means that there is a significant difference in the mean value of the groups (Pallant, 2005). In this case, this means that there is a significant difference in the view of respondents from different professions. However, if the derived p-value is higher than the predetermined significance value of 0.05, it means that no significant difference exists in the view of the respondents.

Findings and discussion

BACKGROUND INFORMATION

The result on the background information of the respondents revealed that more responses were received from Quantity Surveyors and Project Managers (25% each). This is followed by Data and Information technicians (16%), Architects (13%), Civil Engineers (9%), Contracts Manager (6%), Electrical engineers in telecommunication (3%) and Town planners (3%). Also, most of the respondents (40%) have a Bachelor degree. This is followed by a National Diploma with 38%, Post-matric Certificate with 16% and Masters degree with 6%. In terms of years of experience, 56% have five years of working experience, 29% have between 6 to 12 years, 6% have between 13 to 18 years, 3% have between 19 to 24 years while 6% have above 24 years working experience. The average years of working experience of the respondents are calculated as 8.7 years. This result shows that the different professions within the construction industry are represented in the study. Similarly, the respondents for the study are equipped in terms of academic background and years of experience within the built environment to constructively interpret the questions asked and give a significant response to the questions of the study. The response received from them can be relied upon as they were given based on their experience.

DRIVERS OF SMART CITY DEVELOPMENT

Smart Environment Drivers

The result in Table 1 shows the ranking of the different smart environment drivers that can lead to smart city development. The premise for ranking is that the variable with the highest mean score is ranked first while subsequent ones are ranked after it. However, where two or more variables have the same mean score, the one with the lowest standard deviation (SD) as ranked first, as suggested by Field (2005). The Table also shows the chi-square (X^2) and significant p-value derived from the Kruskal-Wallis H-test. From the result, it is evident that there is no significant difference in the view of the different respondents with regards to the significance of the drivers identified as a significant p-value of above 0.05 is derived for all assessed variables. This shows that the ranking can be relied upon as respondents had a similar view of the significant smart environment drivers needed for smart city development in South Africa. A cursory look at the mean values of all the assessed variables shows that they are all from 4.0 and above. This shows that this driver is crucial to the attainment of a smart city. More significant is decreasing pollution levels and monitoring water and electricity consumption using smart meters. These variables all have a mean value of 4.31 each. On the overall, smart environment drivers have a mean value of 4.18, which shows a high level of significance. This high level of significance can be associated with the fact that the whole concept of attaining city smartness is centred around protecting and sustaining the environment.

The importance of control and management of the city's utility systems has been noted in past studies (Bawa *et al.*, 2016). Washburn and Sindhu (2010) have earlier noted that the use of smart meters allows efficient utilisation of utilities within a city. Similarly, it allows proper monitoring and control of these utilities. Findings of this study support this submission as the use of smart meters to control water and electricity consumption are significant smart environment drivers for smart city development in South Africa. The clamour for a safe environment, free of environmental pollution is not a new issue. The European Union (2014) and the European Chronic Disease Alliance (2015) have noted the high level of air pollution in most urban cities. If a safe and healthy city is to be achieved, then the reduction of pollution levels through the implementation of policies and strategies is necessary.

Table 1   Smart Environment Drivers

Smart Environment	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Decrease pollution levels	4.31	0.821	1	6.852	0.444
Smart Meters to monitor water consumption	4.31	0.861	1	6.571	0.475
Smart Meters to monitor electricity consumption	4.31	0.897	1	7.214	0.407
Increase of green public spaces	4.25	0.718	4	6.345	0.500
Improve ecological awareness	4.03	0.896	5	6.850	0.445
Improve waste management systems	4.03	0.592	5	7.962	0.336
Electricity conservation using dim sensors	4.00	1.136	7	5.486	0.601
Group Mean	**4.18**				

Smart Economy Drivers

The result in Table 2 shows the result for the smart economy drivers assessed. Under this group, all the 7 variables assessed has a mean value of above average of 3.0. On the overall, the mean value for this group is 3.94 which is considerably high. Most significant among these drivers are support growth of formal sector (*MIS = 4.03, p-value = 0.222*), expansion of the knowledge capital of the population (*MIS = 4.00, p-value = 0.226*), encouraging entrepreneurship and innovation (*MIS = 4.00, p-value = 0.355*), and international integration (*MIS = 4.00, p-value = 0.130*). Kruskal-Wallis H test revealed that while no significant difference exists in the view of the respondents with regards to 6 out of the seven assessed variables, there is some disparity in their rating of 'growth of the informal sector' as a smart economy driver. A p-value of 0.037, which is less than the 0.05 threshold, was derived for this variable.

For a smart city to be achieved, growth must be encouraged particularly by encouraging entrepreneurial skills and innovation as observed by (Giffinger *et al.*, 2007). Peberdy and Götz (2016) have earlier noted that through this encouragement, the formal and informal sector of a city can grow. Findings of this study further affirm these submissions as professionals believe that providing support for the growth of the formal sector, and encouraging innovation and entrepreneurship are two key smart economy drivers needed for a smart city to be attained in South Africa. The findings of the study also corroborate the submission of Alfano, Amitrano and Bifulco (2014) that promoting increased external funding through international integration is germane to smart economy attainment. Similarly, the findings are in tandem with the submission of Angelidou (2015), that knowledge capital of urban population plays a crucial role in the attainment of smart cities.

Table 2   Smart Economy Driver

Smart Economy	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Growth of formal sector	4.03	0.695	1	9.450	0.222
Population knowledge capital expansion	4.00	0.762	2	9.388	0.226
Encouraging entrepreneurship and innovation	4.00	0.842	2	7.752	0.355
International integration	4.00	0.916	2	11.204	0.130
Improved productivity of the workforce	3.91	0.689	5	5.952	0.545
Improved city competitiveness	3.88	0.751	6	6.142	0.523
Growth of informal sector	3.75	0.916	7	14.889	0.037**
Group Mean	3.94				

** Significant at $p < 0.05$

Smart People Drivers

In terms of smart people, the result in Table 3 shows that all the smart people variables assessed have a mean value of 4.00 and above. This shows that this dimension plays a significant role in the attainment of smart cities. On the overall, this dimension has

a mean value of 4.12, which is far above the average of 3.0. Chief of these drivers are improved education and facilitating lifelong learning with a mean value of 4.34 and 4.16, respectively.

Table 3   Smart People Driver

Smart People	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Improved education	4.34	0.602	1	4.263	0.749
Facilitate lifelong learning	4.16	0.767	2	6.588	0.473
Smart Technologies in libraries	4.06	0.759	3	4.095	0.769
Promote an equitable society	4.03	0.967	4	6.311	0.504
Encourage community collaboration	4.00	0.880	5	9.244	0.236
Group Mean	4.12				

Kruskal-Wallis H Test revealed no significant difference in the view of the different respondents regarding the significance of the drivers identified as a significant p-value of above 0.05 was derived for all assessed variables. In past studies, the role of education has been emphasised. Malabi (2018) noted that the problem of smart city attainment is not that of the availability of technology, but that of cohesion, education and utilisation. Aghimien et al. (2019) also affirmed that it is only through proper education that the understanding of digital-related practices and improvement on their sutilisation can be achieved. Findings of this study further confirm these submissions as improved education is believed to be a key driver of smart people in the quest for smart cities in South Africa.

Smart Governance Drivers

In terms of smart governance, four variables were assessed. All assessed variables had a mean value of above 3.0 with the most significant being improved public and social services (*MIS = 4.38, p-value = 0.179*) and transparent governance (*MIS = 4.06, p-value = 0.225*). The overall mean value of the group is 4.04, which shows a high level of significance. The result from the Kruskal-Wallis H Test also showed that the respondents had a convergent view as to the significance of these variables as a significant p-value of above 0.05 was derived for all assessed variables. Rana *et al.* (2018) have earlier observed that governance is a major issue in attaining city smartness. Chourabi *et al.* (2012) have also stated the need for better governance to manage several cities initiatives effectively. This is a pointer to the fact that the role of good governance in the delivery of smart cities cannot be overlooked. Providing improve public and social services such as poverty alleviation programs, and infrastructure development is essential, as noted in the findings of this current study. This finding further corroborates the submission of Aghimien *et al.* (2019) and Ghosal and Halder (2018) who noted the need for government to provide basic social amenities to cities in a bid to first squash the inherent challenges being faced within the city and thereon creating strategies for the attainment of a more digitised city. Also, having a transparent government will go a long way in increasing citizens' confidence in the government and encouraging citizen participation in the attainment of smart cities. This

finding is in tandem with the submissions of Alfano, Amitrano and Bifulco (2014), Gcaza (2018) and Ghosal and Halder (2018) who observed that smart governance is strategically driven by transparency and accountability in government.

Table 4   Smart Governance Driver

Smart Governance	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Improved public and social services	4.38	0.833	1	10.171	0.179
Transparent Governance	4.06	0.914	2	9.406	0.225
Resourceful e-governance platforms	3.94	0.914	3	11.369	0.123
Improve political awareness	3.78	0.941	4	5.915	0.550
Group Mean	4.04				

Smart Mobility Drivers

The smart mobility driver is championed by green modes of transport (*MIS = 4.06, p-value = 0.077*), expanded international accessibility opportunities (*MIS = 4.03, p-value = 0.312*), and affordable ICT infrastructure (*MIS = 4.00, p-value = 0.391*) as seen in Table 5. An overall mean value of 3.92, which is far above the average of 3.0 was derived for all the assessed variables. Kruskal-Wallis H Test also revealed that there is no significant difference in the view of the respondents regarding the significance of the smart mobility drivers as a significant p-value of above 0.05 was derived for all assessed variables. The findings of this study are in line with the submission of Giffinger *et al.* (2007) who noted that through expanded international accessibility and the availability of ICT infrastructure smart mobility can be achieved within a city. Similarly, the findings of the study further confirm Deloitte (2014) submission that smart mobility strives to reduce the emission of greenhouse gases produced through the excess use of cars within the city. This can be achieved through a green mode of transportation which strives to encourage the use of public transport systems and reduced private vehicles on the roads. Through this, air and noise pollution, traffic congestion, and safety of citizens are improved as observed by Bencardino and Greco (2014) Giffinger *et al.*, (2007) and Peprah, Amponsah and Oduro, (2019).

Table 5   Smart Mobility Driver

Smart Mobility	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Green modes of transport	4.06	0.759	1	12.816	0.077
Expand international accessibility opportunities	4.03	0.782	2	8.237	0.312
Affordable ICT Infrastructures	4.00	0.803	3	7.375	0.391
Smart utilities such as Smart Parking App	3.59	0.875	4	8.688	0.276
Group Mean	3.92				

Smart Living Drivers

The result in Table 6 shows that all assessed smart living variables had a mean value of above average of 3.0. More significant among them are improved health care delivery, innovative educational institutions, enhanced security, and advance the quality of housing with a mean value of 4.47, 4.31, 4.16 and 4.09, respectively. The overall mean value for this group is 4.01, which shows that this group is highly significant to the attainment of smart cities. No disparity exists in the view of the respondents about the significance of the variables on this group as a Kruskal-Wallis H Test gave a p-value of above 0.05 was derived for all assessed variables. This finding is in line with the submission of Giffinger *et al.* (2007) and SALGA (2015) which noted that smart living within a city is driven by innovative education and improving health care services. It is also in tandem with the submission of Colldahl, Frey and Kelemen (2013) who noted that smart living is driven by improved safety of individuals using surveillance cameras throughout the city.

Table 6   Smart Living Driver

Smart Living	MIS	SD	Rank	Kruskal-Wallis	
				X^2	Sig.
Improve health care delivery and services	4.47	0.621	1	4.412	0.731
Innovative educational institutions	4.31	0.738	2	11.12	0.133
Enhanced security	4.16	0.677	3	7.182	0.410
Advance quality of housing	4.09	0.818	4	13.798	0.055
Increase city's capacity to attract tourists	3.94	0.759	5	8.852	0.263
Spur the formation of socially cohesive communities	3.88	0.793	6	10.717	0.151
Modernise existing cultural and leisure facilities	3.75	0.984	7	6.365	0.498
Increase cultural and leisure facilities	3.50	1.136	8	8.653	0.279
Group Mean	4.01				

DISCUSSION AND IMPLICATIONS OF OVERALL SMART CITY DRIVERS

Based on the findings relating to the group mean of each smart city dimension, it can be deduced that while all six assessed dimensions are significant as they have a group mean of well above average of 3.0, the major dimensions wherein significant attention is required are smart environment, smart people, smart governance, and smart living with a group mean value of 4.18, 4.12, 4.04 and 4.01 respectively (see figure 1).
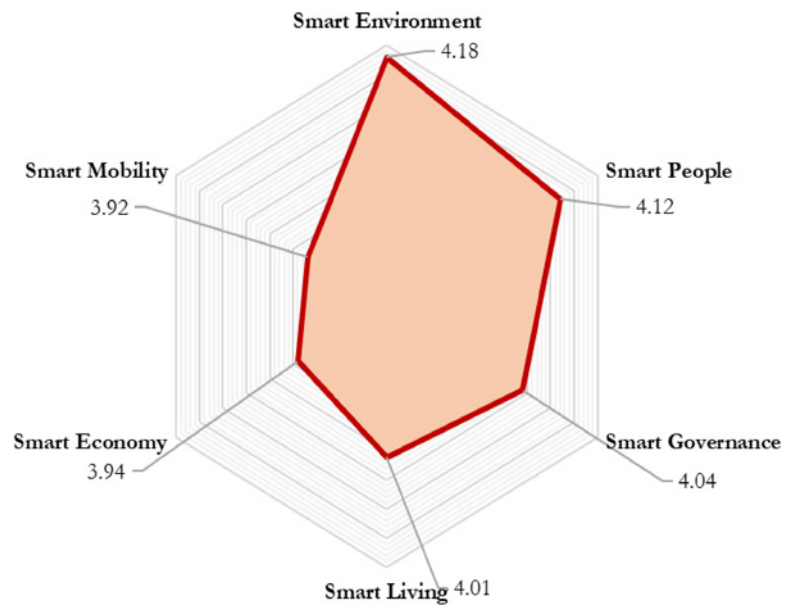
Figure 1   Overall group mean of the smart city drivers

Figure 2 shows a diagrammatic representation of the significant drivers of smart city development in South Africa based on the perspective of selected professional's involved in city smartization. The variables selected under each driver has at least a 4.0 mean value considering that most variables fall around this mean value and above. This result shows that based on a professional's opinion, having a smart environment is the first major step towards having smart cities in South Africa. This is understandable as the rapid urbanisation being experienced in most countries has placed severe strain on the environment and its limited resources, hence the quest for a sustainable and digitised city (Aghimien *et al.*, 2019; Datta, 2015; Dawe and Paradice, 2016). This can be achieved through proper utility management and control as well as decreasing pollution levels as observed in previous studies (Bawa *et al.*, 2016; European Chronic Disease Alliance, 2015; Washburn and Sindhu, 2010).

   In the same vein, the role of the people cannot be overemphasised in the quest for a smart city. South Africans must strive to improve themselves through education and continuous learning. They must be willing to participate actively in public life, increase their education, creativity and flexibility level as observed by Giffinger *et al.* (2007). The government must also be willing to champion this course through the provision of the necessities needed for survival and the attainment of improved education. Provision of improved public and social services that include good internet connectivity and access to information can go a long way in improving people's smartness in the city. Similarly, the government must be transparent in its dealings, digitalise its records and run an open data system as well as engaging its citizens (Alfano, Amitrano and Bifulco, 2014; Gcaza, 2018; Ghosal and Halder, 2018). While these are in place, the smart living must also be given considerable attention as it has been observed that the whole idea of attaining city smartness revolves around creating a better living condition for the city's citizens (Aghimien *et al.*, 2019; Macke *et al.*, 2018). Care must be given to health care delivery (SALGA, 2015), creating innovative educational institutions that can help to shape the thinking

and creativity of the citizens (Giffinger *et al.* 2007), enhanced security (Colldahl, Frey and Kelemen, 2013), and advance the quality of housing.
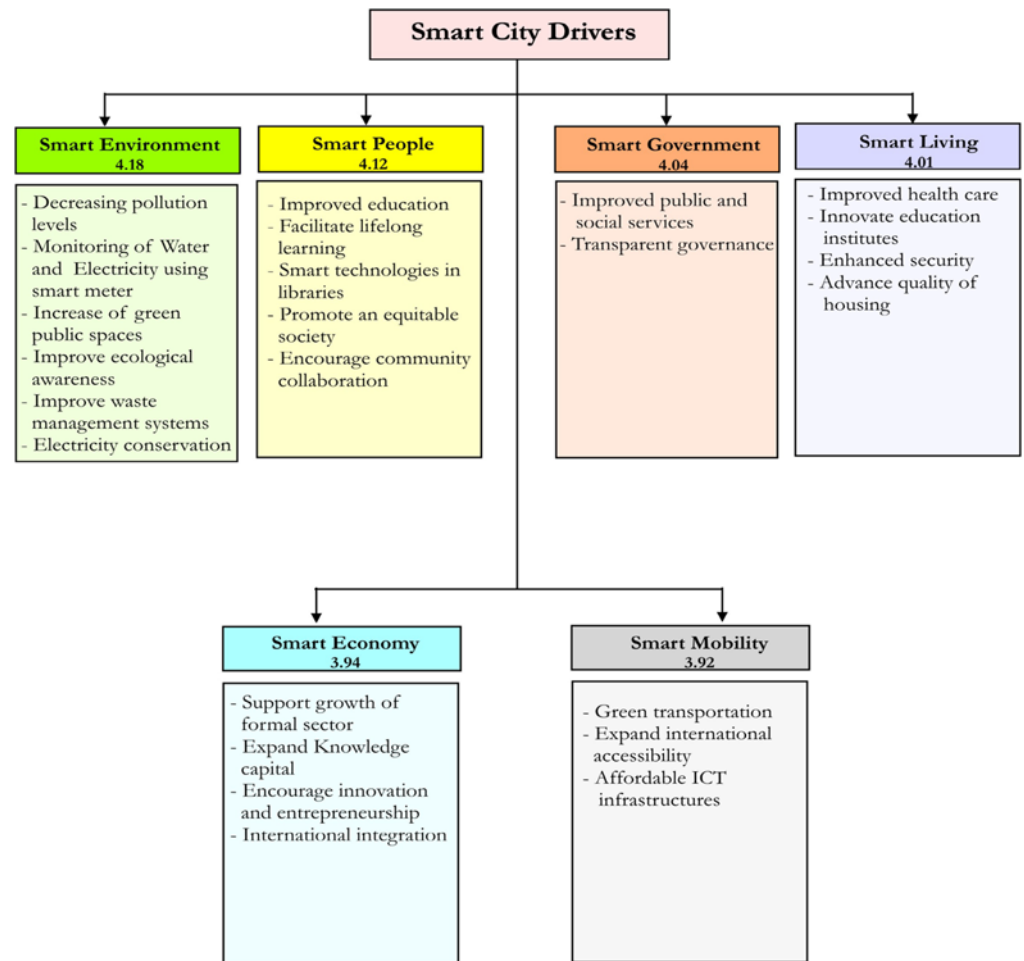

Figure 2　Developed key drivers for smart city development in South Africa

Conclusion

This study assessed the drivers of smart city development in South Africa through the survey of professionals currently practising in the construction industry in Gauteng province. Based on the findings, the study concludes that all six assessed smart city dimensions needed for the attainment of smart cities in the country were considered significant. The implication of this is that to attain smart cities, decreasing the pollution levels within cities, and the city's utility management and control using smart meters must be a priority of the government. Equally important is the provision of improved education and facilitating lifelong learning among South Africans, provision of public and social services and government transparency, improved health care delivery, innovative educational institutions, enhanced security, and improving housing quality. Aside from the key drivers, smart economy and mobility drivers such as support growth of the formal sector, encouraging entrepreneurship and innovation, international integration, expansion of the knowledge capital of the population, green modes of transport, expanded international accessibility opportunities, and affordable ICT

infrastructure should also be given due consideration to achieve holistic smart cities with South Africa.

The findings of this study contribute to the body of knowledge as it brings to light important drivers of smart city development in South Africa; an aspect that has not to gain considerable attention in the discussion of smart cities in the country. The smart city model and its associated drivers is a workable, adaptable and efficient city design mechanism that will be useful for city planners, statutory agencies as well other stakeholders in the achievement of cities that can enhance the quality of life of the citizen, thereby assisting in the sustainable management of resources. However, care must be taken in generalising the findings of the study due to some limitations. First is the possible selection bias in the sample for the study. Further studies can be conducted with a larger population of construction professionals with a diverse view of construction as against using only those involved in smart city development as seen in this current study. Also, this current study was restricted by geographical scope as it was conducted in Gauteng province of the country. Further studies can, therefore, be conducted within other provinces of the country to get a larger sample size.

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