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Improving resilience of cities through smart city drivers

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Abstract

The embracement of smart city approach as a sustainable system for the management and delivery of infrastructural developments has been on the increase, especially in developed and some developing countries. For this to be successful, cities in these countries, particularly in developing ones like South Africa, needs to be resilient because even though resilience can be achieved by making cities smart, smartness does not bring resilience by default. Thus, this study examines various factors influencing the ability of cities to develop resilience through smart city drivers. A survey of construction professionals involved in the design, planning, development and general management of cities and their infrastructure was carried out with the aid of a well-structured questionnaire. Factors influencing resilience were grouped into five divisions which are climate change, education, food security, public safety and threat to disease, in order of their importance. Findings revealed that the most important of these factors are the development of literacy and technical skills of citizens, regeneration of agricultural land and increased localised food production. The paper further examined the effects of these factors on six smart city drivers and found out that smart economy has the most influence on the resilience of a city. It was concluded that stakeholders concerned with the achievement of resilient smart city must give attention to the major needs of its citizens, and such needs are better produced locally.

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Information Technology, Resilient City, Smart City, Smart Technology, Social Cohesion, Sustainable Construction.

Introduction

The word "Resilience" has been adjudged by Valdés, Amaratunga and Haigh (2013) as a new term comparatively gaining usage in policy debates as well as academic publications to refer to how the society suppresses its vulnerability to hazards caused by nature and humans. Resilience was further elaborated by Carpenter *et al.* (2001) to explain socio-ecological systems interaction which was supported by Twigg (2007) as the community's ability to adequately manage disturbances. In making a city resilient, its present level of vulnerabilities need to be carefully assessed and detailed (Parvin *et al.*, 2011). For cities in South Africa (SA) to cope with the present and future requirements of its dwellers, there is a need to promote city development through sustainable approaches such as making the cities resilient (Das, 2012). With these sustainable approaches included in policy planning strategies, cities can be transformed and made smart. To ensure cities are sustainable in some decades to come, city-level authorities needs to be provided with policies, strategies, and platforms that are developmental. This will assist in making the citizens resilient savvy and the environment adaptive thereby transforming the cities (Harrison *et al.*, 2014). Also, there must be proper planning spurred by state officials, community representatives, and experts through collaboration and participation for resilience to be achieved (Wijsman and Feagan, 2019).

Urbanisation is one of the major factors which needs to be solved for cities to be resilient and Smart City initiatives have proven to be able to provide solutions to this problem (Alcatel, 2012; Nama and Pardo, 2014; Oke, Aigbavboa and Cane 2018). Das (2012) submitted that modern technological advancement is capable of making components of a city interlinked with its infrastructures such that standard of living, economic and social wellbeing of dwellers will be improved. This process is referred to as "Smartization". Smart City initiatives give inhabitant the necessary comfortability needed to live in urban cities (Alfano, Amitrano and Bifulco, 2014). According to Elmqvist, Barnett, and Wilkinson (2014), Moglia *et al.*, (2018) and Pelling *et al.*, (2018), for reduction in disaster risks and climate change adaptation globally, urban planning is a major factor to be considered. A resilient city is, therefore, an urban community capable of establishing and hasten an adaptable and equitable relationship between the civic elements and hard infrastructures available within the city (Godschalk, 2003). With the relationship established, modification can be made to the civic elements and infrastructure systems to enable it to cope with the natural pressures as well as internal and external crises that may occur. These civic elements include schools, agencies, health centres, libraries among others that form the social and institutional components in the society while hard infrastructures include built roads, buildings, energy facilities, waterways among others (Godschalk, 2003). However, the authorities of regional, national or urban districts economic eco-system must be afforded focus in the transformation process. This is supported by the submission of Bormann and Gulati (2014), that emergence of a resilient economy is the fundamental component for an urban district as it helps in mitigating water, food and energy insecurities. According to the United Nations estimates, by 2050, about 66% of the world's population will reside in urban cities with 90% of this

trend happening in Africa and Asia (Sha and Sonn, 2015). This shows that there will be need to ensure cities in Africa are resilient to cater for the daily pressure to be imposed by the dwellers. In doing so, the concerns of resource securities, provision of basic services and the creation of knowledge and employment opportunities are alleviated (Municipalities of South Africa, 2016).

Globally, "Cities in Motion Index (CIMI)" rank cities on an annual basis using index facilitated by "IESE Business School at the University of Navarra". The sole aim of the ranking is to establish a "system of measurement for the future resilience and sustainability of the world's main cities as well as the quality of life of the inhabitants". Berrone and Ricart (2016) put forward the ecosystem functionality of urban districts stressing the need to understand how the city networks and components are co-dependent and how they can be improved to make the district resilient. Four South African cities (Cape Town, Johannesburg, Pretoria and Durban) were analysed in the CIMI publication from 2013 till date (Oke, Aigbavboa and Cane 2018). The analysis shows that these cities in South Africa are experiencing urbanisation and as such, necessary steps must be embarked upon to make them resilient. This study, therefore, set out to assess the factors influencing the resilience levels of a city as well as the capabilities of smart city drivers to improve the resilience of a city. Various studies have been carried out on the resilience of South African cities (Harrison *et al.*, 2014; Turok, 2014), however, attention has not been focused on the capability of smart city drivers in improving the resilience of a city which is the specific knowledge gap this study will fill.

Review of city resilience

When making a city resilient, current infrastructures, resources, citizens and sub-systems' potentials must be fully acknowledged. A careful and detailed evaluation of the present level of resilience and vulnerability must also be carried out (Parvin *et al.*, 2011). Simultaneously, authorities must provide an avenue that will help citizens within the urban district cope with the changes that will occur as the city is transformed (Municipalities of South Africa, 2016). If adaptation is tied-in with shaping the future through decisions on what to improve, hold and dispose-off in the existing systems of an urban district, resilience helps set the edge of reference to give logical opinions to these choices (Goldstein *et al.*, 2015). Resilience is therefore designed to go beyond restoring functionality but to also make corrections to economic, political and social structures that have been in place to cope with hazards (Patel and Nosal, 2016). A typical case study is a research carried out by Meunier, Ferrero and Kubicki (2017), which explored the incorporation of smart city drivers into the resilience plan of Luxembourg projected for 2060. The study outlined the major requirements that need to be put in place to achieve resilient systems using a holistic smart city approach. The requirements are the six dimensions of smart city with a focus on achieving economic, social and environmental sustainability. However, it was submitted that the smart city concept is designed such that all the development strategies are placed around the people.

Factors influencing resilience level of a city

Different researchers have been able to identify some factors that influence the resilience level of urban regions through research surveys and studies (Godschalk, 2003; Harrison *et al.*, 2014; National Treasury, 2016). The highlight of these factors is discussed below.

KNOWLEDGE CAPITAL

Knowledge capability of the urban district dwellers is a major factor that influences the resilience of a city. This, therefore, necessitates the need to exert an optimum knowledge capital standard among the citizens (The National Population Commission (NPC), 2012). According to Wijsman and Feagan (2019), planning a resilience city requires knowledge system which is aimed at "understanding resilience within the locality and specific systems; embrace values such as a plurality of perspectives, collective problem framing, and societal agenda setting; and recognizes the need to pay analytical attention to those practices that keep certain patterns of thinking in place". Skill development programmes are therefore needed for learning and development opportunities to be promoted through technology-savvy equipment usage within the district public facilities (Municipalities of South Africa, 2016). In a research study conducted by Ringwood (2015), a submission was made that the technical capabilities of urban dwellers must be the major priority of national and urban stakeholders to enhance technological aptitude in the city. Such an effort will result in the formation of pro-active platforms with the embodiment of national and local economies capable of delivering the desired technological advances. Furthermore, the World Bank (2007), accentuated the aforementioned by highlighting the benefits attached to improving the educational standards of the citizens within the urban district. This has the potential to improve social cohesion among citizens as well as their financial status. The NPC (2012) emphasised the regress in knowledge aptitude development of workforces in South African organisations. For a city planning to be resilience, this phenomenon needs to be addressed immediately for success to be achieved. To this end, the scope of the National Development Plan (NDP) 2030 as proposed by the South African NPC, caters for the deployment of skill learning programmes. These programmes will only materialise and achieve their desired target when organisations collaborate with established civic enterprises.

FOOD SECURITY

Food security is largely dependent on the quantity of food produced internally in a country. When there is a need to import food from other countries due to insufficiency, food price increases which pose a threat to food security (Merwe, 2011). This is corroborated by Ruel and Garrett (2004) who opined that complex food distribution chain which results from food importation from other countries gives room for food insecurity since income availability goes hand-in-hand with access to food. According to Béné *et al.* (2016), advancing development and resilience plays a major role in nutrition and food security as a "mobilising metaphor". This happens such that there must be a linkage between the health sector, social protection sector, livelihood sector and nutrition sector which is been disconnectedly operated traditionally. As submitted by Municipalities of South Africa (2016), the ever-growing climate change effect coupled with urbanisation is contributing majorly to South African cities' food security concerns. This has resulted in the promotion of urban agricultural sub-system growth by city governments through agricultural land regeneration (Department of Planning Monitoring and Evaluation (DPME), 2014). Objectively, this land regeneration initiative is expected to improve and facilitate the cities' ability to extend local products and also launch a solid collaboration between local produce suppliers and food marketers (Spencer *et al.*, 2010; Municipalities of South Africa, 2016). However, food security concern in South Africa coupled with some other shortage of resources cannot be wholly weighted on change in climate as corrupt practices among government officials also suppress the efforts of stakeholders in the food sector (Chipkin and Ngqulunga, 2008).

HEALTHCARE SYSTEM

Food utilisation is one of the dimensions of food security which indicates the eating pattern of different ethnic groups and individuals within the city. Types of food consumed and the diet lifestyle of the citizens eventually have effects on their health which becomes a challenge to the city at large in the long run (Merwe, 2011; Oke, Aigbavboa and Ngema 2017). High consumption of fats which has been recorded among urban dwellers leads to "diet-related non-communicable diseases" such as diabetes and obesity (Bourne and Steyn, 2000). Improvement in hygiene facilities will bring a decrease in the risk of transmissible diseases. Therefore, making clean water available will help in the formation of a healthier city (NPC, 2012). Merwe (2011), added that there is a high intake of tobacco in South Africa which leads to lung cancer and eventual death. Even though cities around the world are aiming at transforming to healthy regions, processes and programmes that will assist in reducing communicable and non-communicable diseases risks, they remain a major concern. Having identified HIV/AIDS as the deadliest disease in South Africa with current statistics showing 22% of deaths caused by HIV/AIDS increased level of awareness needs to be put in place to improve citizens' knowledge of this disease (Statistics South Africa, 2018). Citizens must be empowered while adequate awareness knowledge must be passed across on these diseases. Increase in the awareness level will help citizens to understand the repercussion of their decisions which will, therefore, guide their choices (Ruel and Garrett, 2004). This will also help individuals in knowing the symptoms, treatment packages, and available mitigation options thereby promoting the transformation of the city to pro-active and healthy societies (Municipalities of South Africa, 2016). Another way to improve the health status of citizens is to encourage cycling and walking within the city rather than driving vehicles or using other means of transportation to enable them to do exercises and workout (Municipalities of South Africa, 2016). A survey by Harrison *et al.* (2014) indicated that there is a decline in the wellbeing of South African working class which is affecting productivity at work thereby impacting economic development.

CLIMATE CHANGE

According to Chan (2017), faster warming is associated with the climate systems of urban areas compared to rural areas. These rural areas have water bodies, less built-up areas and vegetation which helps regulate the temperature. It was further opined that the size of the city determines the warming potential with megacity centres experiencing about 7-10°C heat more than rural areas with the fossil fuels used in urban areas contributing largely to this heat increase. Climate change talks about the fluctuations observed in the weather patterns worldwide due to the global warming effects and pollution increase in the environment. This has resulted in the drastic changes experienced in weather conditions globally coupled with supernatural events occurring on a global front (Municipalities of South Africa, 2016). As proposed by NPC (2012), if enough capital can be injected into the energy sector in South Africa, improved infrastructures will be achieved. With this implementation, the level of pollution will be reduced while climate change effects will be minimised. In addition, the usage of environmentally friendly resources can be facilitated when modernisation is injected into the energy sector (Bormann and Gulati, 2014). This can be in the form of using solar panels, nuclear power stations, gas or wind plants, or other forms of modernised energy generation. Also, the reduction of coal reliance in the country as electricity production primary source will birth environmentally friendly energy sector (NPC, 2012; Municipalities of South Africa, 2016). This will assist in the reduction

of carbon dioxide emissions released into the atmosphere. However, the "South African Department of Energy", estimated that about 65% of electricity generation in the country will still rely on coal by 2030 (Bormann and Gulati, 2014). Implementation of trade-offs among the various sectors and enterprises in the country is another platform that can be used to maintain energy consumption standards. This is a mitigation measure which has recorded success in California with the green taxes inclusion (Spencer *et al.*, 2010). Going forward, multi-functional devices can be implemented to monitor the factors contributing to climate change. These devices give room for resource monitoring by utility providers. One of these multi-functional devices is called "smart meters" which has "flow meters and pressure sensors" that measures the level of consumption electricity, water, gas usage and energy outputs (Cominola *et al.*, 2015). Property developers, private homeowners, and utility providers find these devices very efficient and effective in keeping track of consumption level thereby managing their resources effectively (Cominola *et al.*, 2015; Ringwood, 2015).

PUBLIC SAFETY

The safety of the citizens is a major role the government is expected to play in a city. According to the International Centre for the Prevention of Crime (ICPC) (2016), understanding urban safety and crime prevention changes from each language to another. It is therefore put forward that urban safety and crime prevention "emphasizes the role of residents – or communities – in developing and implementing safety policies. Likewise, the development of personal capacities, whether by education, professional skills development, leadership, etc., promotes good social integration and the building of peaceful living environments". Public safety begins when there is acceptance of the fact that inadequacy of local governance, urban development, and social patterns gives room for violence and crime occurrence (UN-Habitat III, 2015). Higgs (2007) reported that crime level has increased in South Africa and such has raised general fear among citizens, most especially, foreigners, women, and children due to government's failure to build up and keep a close relationship with the citizens. Also, the citizens and city dwellers failed to form good social cohesion among themselves. Greyling (2013) supported the view by reporting that crime in South Africa can only be reduced with the collaboration of local authorities and the citizens. The formation of "Community Policing Forums (CPF)" by the government of South Africa is expected for assist the "South African Police Service (SAPS)" in fighting criminal activities which will alleviate the fear of the citizens. To achieve this, "warning systems" will be implemented, which will aid proactive and effective communication between the CPF, SAPS, and citizens for timely security alerts (Municipalities of South Africa, 2016). Komninos, Schaffers and Pallot (2011), opined that with the development of a "real-time control system" through the usage of ICT-enabled sensors and devices within the city, the following can be achieved: " Individuals, organisations or areas exposed to high levels of risk can be monitored and controlled; detection of an individual, organisation or civic environment being exposed to crime at any time within the city; the provision of a report which enables authorities to analyse and pick up common crime trends; and, expose personnel who delay necessary actions when threats are revealed by the devices to the relevant safety authorities". In conclusion, Calabrese, Kloeckl and Ratti (2009), highlighted the advantages of implementing a systematic analysis of trend platform and crime data as it aids in the process of keep tracking of crime statistics, which can be accessed at any point in time.

Research methodology

To adequately achieve the objective of this study which is to appraise factors influencing resilience level of cities and the influence of the different drivers of a smart city in improving the resilience of cities, quantitative research method was adopted. This method is used by researchers to "provide solutions to predetermined research questions and objectives, by analysing the relationship between the different variables through the use of an experimental or non-experimental data collection instrument (survey), in turn yielding results which are numerical, thus can be analysed using statistics" (Creswell, 2014). The study focused on the three main municipalities that made up Gauteng province of SA which are "City of Ekurhuleni Metropolitan Municipality (EKU), City of Johannesburg Metropolitan Municipality (COJ) and City of Tshwane Metropolitan Municipality (COT) all in the Gauteng province of South Africa. Respondents were chosen from professionals who have knowledge about smart cities and resilience cities within Gauteng province which include Contracts Managers, Project Managers, Town Planners, Quantity Surveyors, Civil Engineers, Architects, Data technicians (IT) and Electrical Engineers. The total number of the target population could not be ascertained as the study requires respondents to have a minimum of 5years experience in the construction industry coupled with adequate knowledge of smart cities and the resilience of cities. This, therefore, led to the adoption of snowball sampling technique to reach out to the respondents, and a total of 32 were identified. To carry out the snowball sampling technique, a primary network of professionals currently executing projects classified under smart city projects (smart transportation, smart security, smart living) was identified first and were sent the questionnaires electronically. They were further obliged to distribute the questionnaire to colleagues who meet up with the study's target population criteria. A similar technique was adopted in the research study carried out by Ajibade (2017), Huck and Monstadt (2019) and Sharifi (2019). The survey of opinion from respondents for this study employed a close-ended questionnaire which addressed the set objectives of the study. The questionnaire was designed into three sections based on identified variables from reviewed literature. The first section addressed respondents' background information while the second section addressed the various factors influencing resilience level of cities as identified in Godschalk (2003); Harrison *et al.*, (2014); Béné *et al.*, (2016); Malalgoda, Amaratunga and Haigh (2016); Moglia *et al.*, (2018); Borie *et al.*, (2019); Martins, Rodrigues da Silva and Pinto (2019) under education, food security, health system, public safety, and climate change arms using a 5-point agreement Likert scale. These are the five arms of city resilience. The third section harnessed information related to the usage of smart city drivers which are smart economy, people, mobility, governance, environment and living for increasing the resilience level of cities as identified in Colldahl, Frey and Kelemen (2013); Letaifa (2015); Sha and Sonn (2015); Oke, Aigbavboa and Cane (2017) using a 5-point agreement Likert scale.

Test of reliability and validity was carried out on the retrieved data using Cronbach's alpha, and the result showed 0.935 value. According to Tavakol and Dennick (2011), with the Cronbach's alpha value ranging between 0.70 and 0.95, the statistical tool is reliable, and values close to 0.95 represents a high level of inter-dependence between the different concepts being measured or investigated in the study. Retrieved data was analysed using Mean Item Score (MIS), which is the main analysis carried out to rank the variables based on respondents' agreement to individual variables. The ranking is done in descending order such that the variable with the highest mean value is ranked first followed by subsequent high values. A further analysis was carried out using Kruskal-Wallis H-test. This was adopted since there

are different groups of respondents used for the research study, and there is a possibility of disparity in their opinion towards the identified variables. Kruskal-Wallis H-test determines if there is a difference in the median of groups that make up the respondents. The significant p-value obtained from the analysis must be greater than 0.05 to establish that there is no disparity in the opinion of the respondent groups (Pallant, 2011).

Findings and discussion

BIOGRAPHICAL INFORMATION OF RESPONDENTS

From the analysed data, Diploma certificate holders among the respondents are 16%, National Diploma certificate holders formed 38%, 40% are Bachelor degree certificate holders while 6% have Masters degree certificate. In terms of professional qualification, 3% of the respondents are Town Planners while Contract Managers, Civil Engineers, and Architects are 6%, 9% and 13% respectively. 25% of the respondents are Project Managers and Quantity Surveyors each, 3% are Telecommunication Electrical Engineers, and 16% are Data and Information Technicians. The largest number of the respondents works as Principal Contractor (41%), 34% works for a Consultancy Firm, 16% works for Information Technology Companies, 6% of the respondents works in a Government Department while 3% works in an Academic Institution. The years of experience analysis shows that 56% of respondents have five years of experience in the construction industry, 28% have 6-10 years of experience, 3% have between 16 and 20 years of experience while 6% have 11-15 years and above 20 years each. The background information gathered from the respondents shows they have adequate professional qualification coupled with tangible years of experience and the needed knowledge to give a professional opinion as regards the objective of this study.

INFLUENCE OF EDUCATION ON RESILIENCE

Figure 1 shows the influence of education on urban districts based on the respondent's view. From the ranking, citizen's literacy skill development has the highest MIS = 4.44 followed keenly by citizen's technical skill development with MIS = 4.34. Technology savvy social amenities ranked lowest with MIS = 3.78. Kruskal-Wallis H-test in table 1 revealed that there is no statistically significant difference in the opinion of the group of respondents as all the significant values are above 0.05. As pointed out by NPC (2012) earlier, the resilience level a city adopts is dependent directly on the knowledge capacity of its citizens. This is an indication that skills and knowledge development must be implemented so that learning and education level of citizens can be improved through the use of equipment that is technology savvy. Such equipment can be installed in higher institutions, schools, and public centres to build technical and literacy skills. The findings are further supported by Ringwood (2015), who stated that the technical capabilities of urban dwellers must be the major priority of national and urban stakeholders to enhance technological aptitude in the city. The availability of internet facilities in the locality is another major factor that the government needs to focus on as it plays a major role in the education status of the citizens in this 21st century. This will aid the formation of open online universities for access to education for all citizens within the city. Such universities can be subsidised by the government to encourage citizens to get first-hand access to education.

Figure 1 Influence of Education on Resilience.

Table 1 Kruskal-Wallis H-Test for Influence of Education on Resilience

Educational Influence	Kruskal-Wallis	
	Chi-Sq.	Sig.
Citizen's literacy skills development	2.214	0.899
Citizen's technical skills development	4.251	0.643
Internet facilities access in local communities	9.663	0.140
Open online University formation	10.753	0.096
Technology savvy social amenities	12.146	0.059

INFLUENCE OF FOOD SECURITY ON RESILIENCE

Based on the opinion of the respondents, figure 2 reveals the influence of food security on the resilience of urban districts, while table 2 shows the Kruskal-Wallis H-test result. Agricultural land regeneration ranked first with MIS = 4.41 and p. value = 0.201, this is followed by entrepreneur empowerment and localised food production increase with MIS = 4.31, 4.16 and p. value = 0.105, 0.382, respectively. At the bottom of the ranking is international food supply integration with MIS = 3.91 and p. value = 0.402. With the least variable having an MIS of 3.91, this is an indication that food security plays a big role in the resilience level of a city. South African Department of Planning, Monitoring and Evaluation (2014) opined that agricultural land regeneration can promote the growth of urban agricultural sub-systems. This is in agreement with the findings of this study as respondents believe that this will aid localised food production increase thereby creating empowerment for entrepreneurs in the agricultural sector. Spencer *et al.*, (2010) also share this view having pointed out that land regeneration initiative is expected to improve and facilitate the cities' ability to extend local products and also launch a solid collaboration between local produce suppliers and food marketers. The Municipalities of South Africa (2016) also stated that the main objective of the regeneration of agricultural lands is to broaden the local production of agricultural products.

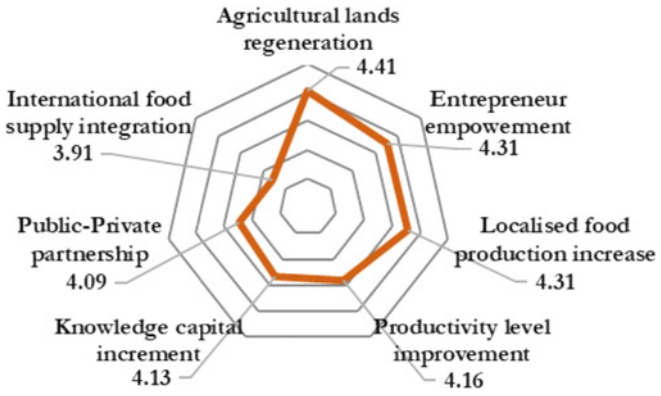

Figure 2 Influence of Food Security on Resilience

Table 2 Kruskal-Wallis H-Test for Influence of Food Security on Resilience

Food Security Influence	Kruskal-Wallis	
	Chi-Sq.	Sig.
Agricultural lands regeneration	8.546	0.201
Entrepreneur empowerment	10.499	0.105
Localised food production increase	6.384	0.382
Productivity level improvement	5.057	0.537
Knowledge capital increment	5.866	0.438
Public-Private partnership	3.612	0.729
International food supply integration	6.193	0.402

INFLUENCE OF HEALTHCARE SYSTEM ON RESILIENCE

The influence of the healthcare system on the resilience level of a city, according to the respondents, is shown in figure 3. All the factors except eradication of transmissible diseases which was ranked fifth have a Kruskal-Wallis p value above 0.05 from table 3. This, therefore, indicates that there is a diverging opinion concerning this factor by the group of respondents as transmissible disease cannot be completely eradicated according to studies (Chan, 2017). Implementation of sanitation services was ranked first with MIS = 4.22, Curbing HIV/AIDS prevalence ranked second with MIS = 3.84, Citizens lifestyle influence on health system ranked third with MIS = 3.81 while Social support networks formation was the lowest with MIS = 3.69. Having a clean and healthy environment is the first step to maintaining a good healthy lifestyle which can be achieved by implementing proper sanitation services within the city. Merwe (2011) reported earlier that types of food consumed, and the diet lifestyle of the citizens eventually have effects on their health which becomes a challenge to the city at large in the long run. Citizens must be given adequate awareness of the type of diet lifestyle that will help keep them in a complete state of wellbeing. NPC (2012) asserted that an improvement in hygiene facilities will bring a decrease to the risk of transmissible diseases, so making clean water available will help in the formation of a healthier city. However, this cannot completely eradicate transmissible diseases but can only reduce it to the barest

minimum. Statistics South Africa (2018) identified HIV/AIDS as the deadliest disease in South Africa. Citizens must be empowered while adequate awareness knowledge must be passed across on these diseases. Knowing the repercussion of decisions taken by the citizens will guide their choices as pointed out by Ruel and Garrett (2004).

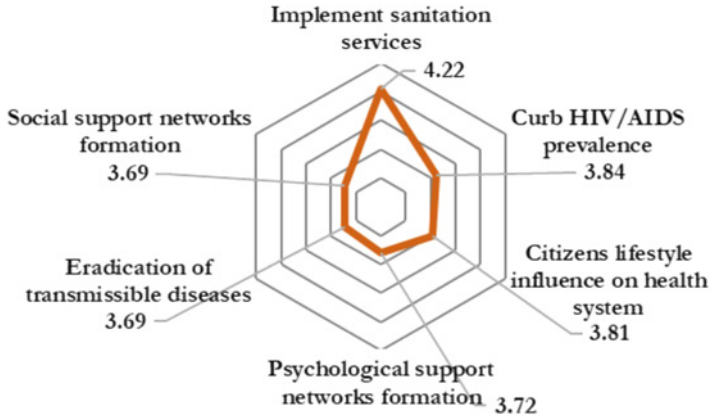

Figure 3 Influence of Healthcare System on Resilience

Table 3 Kruskal-Wallis H-Test for Influence of Healthcare System on Resilience

Healthcare System Influence	Kruskal-Wallis	
	Chi-Sq.	Sig.
Implement sanitation services	5.726	0.455
Curb HIV/AIDS prevalence	6.851	0.335
Citizens lifestyle influence on health system	4.435	0.618
Psychological support networks formation	11.785	0.067
Eradication of transmissible diseases	13.136	0.041**
Social support networks formation	10.595	0.102

** Significant at $p < 0.05$

INFLUENCE OF PUBLIC SAFETY ON RESILIENCE

Figure 4 presents the respondents' opinion on Public safety influence on the resilience level of urban districts, while table 4 shows the Kruskal-Wallis H-test result. From the ranking, Real-time control systems were ranked first with MIS = 4.25 and p. value = 0.596, Crime data and trends platform systematic analysis ranked second having MIS = 4.13 and p. value = 0.551 while Community policing forum formation ranked lowest with MIS = 4.03 and p. value = 0.516. All the variables have MIS above 4.00, which suggests that the safety of citizens life is the major criteria to be considered when the resilience level of a city is being measured. When there is no public safety, citizens tend to migrate to safer regions outside the district. This agrees with the findings of Komninos, Schaffers and Pallot (2011), who asserted that the development of a "real-time control system" through the usage of ICT-enabled sensors and devices within the city would be of great advantage to the city. With the formation of a

community policing forum, SAPS can be assisted in fighting criminal activities which will alleviate the fear of the citizens and ensure the safety of lives as submitted by Calabrese, Kloeckl and Ratti (2009). This will eventually improve the military force of the city and make them well-equipped to tackle crime.

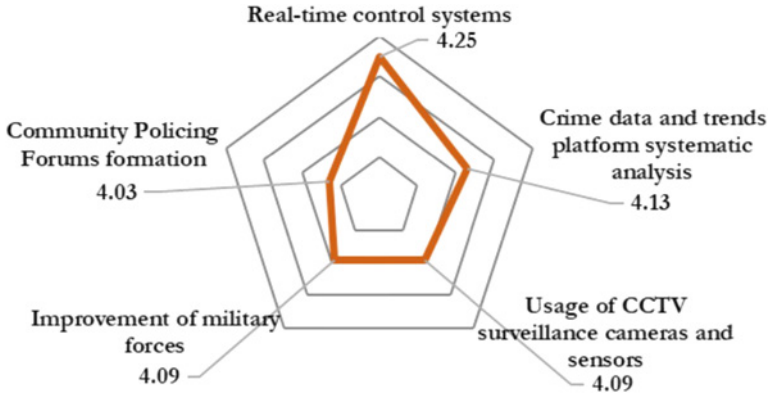

Figure 4 Influence of Public Safety on Resilience

Table 4 Kruskal-Wallis H-Test for Influence of Public Safety on Resilience

Influence of Public Safety	Kruskal-Wallis	
	Chi-Sq.	Sig.
Real-time control systems	4.597	0.596
Crime data and trends platform systematic analysis	4.947	0.551
Usage of CCTV surveillance cameras and sensors	9.089	0.169
Improvement of military forces	7.664	0.264
Community Policing Forums formation	5.220	0.516

INFLUENCE OF CLIMATE CHANGE ON RESILIENCE

Respondents believe that Green infrastructure development and energy conservation are the major factors influencing the resilience of an urban district through climate change with MIS = 4.25 each as shown in figure 5. Eco-mobility strategies ranked third with MIS = 4.06 while Carbon emissions trading system formation was ranked lowest by respondents with MIS = 3.72. As shown in table 5, there is no statistically significant difference in the opinion of the respondents as all the p. values are above 0.05. With the adoption of green infrastructures within South Africa, climate change phenomenon can be managed effectively while energy conservation within the infrastructures will be reduced to a minimum. This has been proposed by NPC (2012) that the injection of enough capital into the South African energy sector will improve infrastructure. Once these infrastructures are in place, the level of pollution will reduce while climate change effects will be minimised. As opined by Bormann and Gulati (2014), the usage of environmentally friendly resources must be facilitated by the energy sector experience modernisation. Formation of a carbon trading emission system will also help in managing the environment as the environment plays a major role in the

wellbeing of city dwellers. According to Spencer *et al.*, (2010), trade-offs implementation among the various sectors can be used to maintain energy consumption standards. Eco-mobility strategies is another factor that requires the attention of policymakers as the adoption of a modern transport system will help to reduce energy emission and consumption.

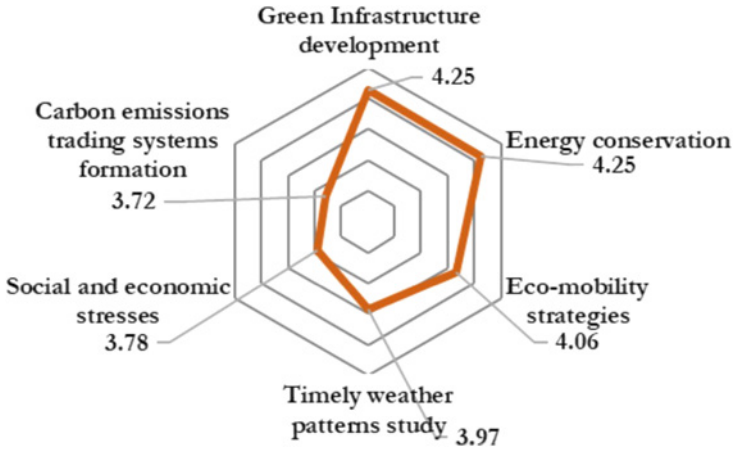

Figure 5 Influence of Climate Change on Resilience

Table 5 Kruskal-Wallis H-Test for Influence of Climate Change on Resilience

Influence of Climate Change	Kruskal-Wallis	
	Chi-Sq.	Sig.
Green Infrastructure development	8.818	0.184
Energy conservation	9.056	0.170
Eco-mobility strategies	6.252	0.396
Timely weather patterns study	8.642	0.195
Social and economic stresses	6.164	0.405
Carbon emissions trading systems formation	2.317	0.888

Having ranked the individual factors influencing the resilience of an urban district, a grouped MIS of the factors is presented in figure 6 as shown below with Food Security ranked first followed by Education and Public safety with MIS = 4.19, 4.15 and 4.12, respectively. Healthcare system ranked fifth with MIS = 3.83, which is below the average total grouped MIS of 4.06. This is an indication that more attention must be paid to food security of the citizens as this determines the state of their wellbeing. As the popular saying *"health is wealth"*, they can only function adequately and efficiently when they are healthy. However, contrary to expectation, the healthcare system does not require much attention probably because once citizens adopt the right diet lifestyle coupled with high educational standard, there will be less need for treatment of diseases which necessitates the provision of healthcare systems.

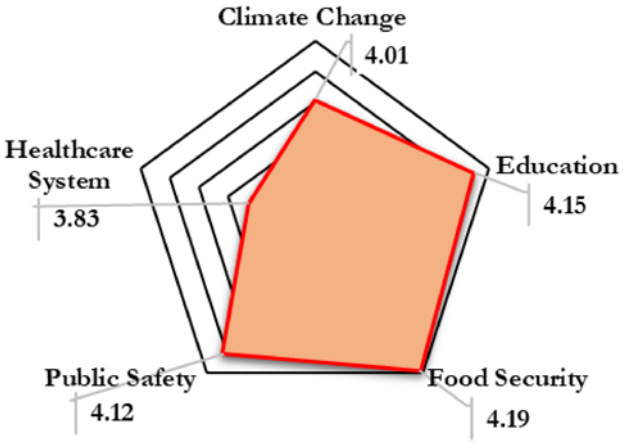

Figure 6 Group Mean Score for Factors influencing Resilience

ROLE OF SMART CITY DRIVERS IN RESILIENT CITIES FORMATION

Findings on the role smart city drivers play in the resilient city formation is shown in figure 7 and table 6. Kruskal-Wallis H-test shows no statistically significant difference in the opinion of the respondents. From the ranking, smart economy has the most influence on the resilience of a city with MIS = 4.22. The smartness of the economy will ensure there are necessary provisions made for what is required to make a city resilient. This is supported by Peberdy and Götz (2016), who opined that deployment and modification of strategies on local, provincial and national levels are dependent on smart economy. This helps in energising an environment that supports informal sector evolution and backs up entrepreneurship within the informal and formal sectors. Smart living ranked second according to the respondents. As asserted by Colldahl, Frey and Kelemen (2013), smart living brings betterment to the society by making provision for individual safety in the city with the use of surveillance cameras. When citizens are living comfortably, resilience cannot be doubted. With MIS = 4.13, smart governance ranked third according to professionals. According to Alfano, Amitrano and Bifulco (2014), smart governance involves having a transparent government that has sound political strategies and considers its citizen's viewpoints in decision making. It is necessary to carry the citizens along in the decision-making process of the government to ensure that the interest of the citizens is well preserved. Smart people followed smart governance which indicates that the citizens must be ready to engage themselves in the activities that upgrade the city. Giffinger *et al.*, (2007) posited that smart citizens must participate in public life, increase in education and creativity and be flexible for human activities. To achieve smart environment, Washburn *et al.*, (2010) and SALGA (2015) asserted that waste disposal and management, electricity usage and conservation of renewable/non-renewable resources coupled with the provision of social amenities that can cater for the city must be accorded proper attention. However, natural environment preservation requires strategy and policy implementation which will be tailored towards reduction in carbon emission associated with urban cities (European Chronic Disease Alliance, 2015). The effect of carbon emission is evident in the different chronic diseases which urban citizens suffer from (Das, 2012; European Chronic Disease Alliance, 2015). With all the smart city drivers having MIS above 4.00, it can be said that smart city drivers are capable of improving the resilience level of cities.

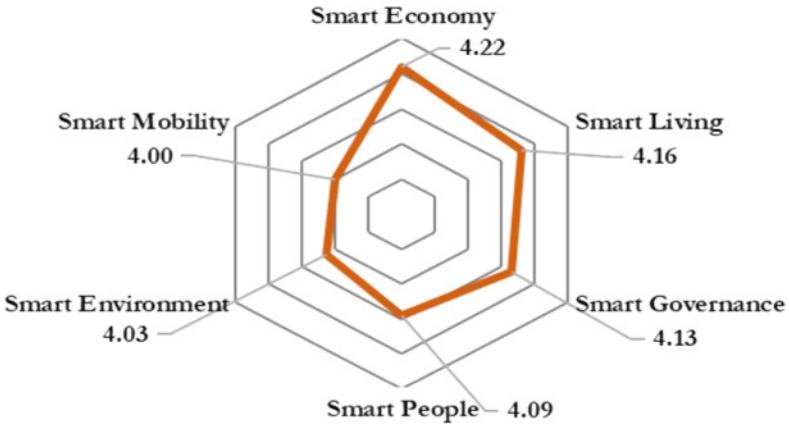

Figure 7 Role of Smart City Drivers in the Resilient City Formation

Table 6 Kruskal-Wallis H-test of Role of Smart City Drivers in the Resilient City Formation

Smart City Drivers	Kruskal-Wallis	
	Chi-Sq.	Sig.
Smart Economy	4.233	0.645
Smart Living	4.617	0.594
Smart Governance	6.283	0.392
Smart People	3.788	0.705
Smart Environment	6.020	0.421
Smart Mobility	2.399	0.880

Conclusion

Having assessed the factors influencing resilience level of a city, and the usage of smart city drivers in increasing the resilience level of cities using a questionnaire survey, the objectives of the study was achieved. Respondents within Gauteng province who have adequate knowledge about smart cities and resilience in cities were used as the target population. From the findings of the study, it can be concluded that all the primary factors identified from literature influence the resilience level of a city. However, climate change, together with education and food security are major factors to be reckoned with if resilience in South African cities is to be achieved. The findings of this study also revealed that smart cities have the potential and ability to assist South African cities achieve the Joburg 2040 GDS goals and also improve the levels of resilience. Although this will require the attention of city-level stakeholders as well as urban citizens. As a result of the smart city drivers' ability to promote empowerment of entrepreneurs, thereby aiding the formation of a thriving informal economic sector, the challenge of unemployment can be adequately mitigated. This will enhance the growth of the SA economy. Given this, city-level stakeholders, as well as urban citizens, should focus on ensuring cities are made 'smart' to improve the resilience of the cities. This can be achieved

by the construction of smart infrastructure and upgrading the smartization of existing infrastructure to meet up with the required standard.

Generally, this study has been able to contribute to the body of knowledge by throwing light to the factors that influence the level of resilience of a city and also assessing the ability of smart city drivers to increase the resilience level of a city. Little research work has been carried out on this area of study and with the government planning to achieve smartization of cities in South Africa, there is a dire need for such study to assist policymakers and regulatory bodies. The findings of the study can serve as a roadmap for emerging economies as these economies will experience rapid urbanisation and there will be a need to make available all the necessary infrastructure to achieve resilience. The findings of this research study if reckoned with, will provide city planners, government authorities, professionals and clients within the built environment with an understanding of the smart city drivers and its usefulness in the development of resilient city systems. This will prompt the creation of a unified community among urban citizens. Further research work can be carried out on the opinion of professionals in the remaining eight provinces of SA on smart cities and resilient systems. This will give an overall knowledge of its implementation.

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