

## TOWARDS SMART CITIES IN SOUTH AFRICA: EVOLUTION, DEFINITIONS, AND FUTURE CITIES

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### ABSTRACT

High urbanisation rates lead to increasing pressure on governments to provide sustainable living conditions. This article aims to explore the approaches that smart city projects around the world use to address some of these challenges. The evolution of cities is landmarked by technological innovation; and the successful use of Internet of Things (IoT) technology seems to be another landmark. In this article the focus falls first on the evolution of cities and the definition and future of smart cities. In part two the focus is on the challenges and opportunities that South Africa faces in its quest to build smart cities.

### OPSOMMING

Hoë verstedelikingsyfers lei tot toenemende druk op regerings om volhoubare lewensomstandighede te voorsien. Hierdie artikel het ten doel om aspekte te verken wat slimstadprojekte regoor die wêreld gebruik om sommige van hierdie uitdagings aan te spreek. Die evolusie van stede word gekenmerk deur tegnologiese innovasie en die suksesvolle gebruik van 'Internet of Things' (IoT) tegnologie blyk nog 'n landmerk te wees. In hierdie artikel val die fokus eerstens op die evolusie van stede en op die definisie en toekoms van slim stede. In deel twee val die fokus op die uitdagings en geleenthede wat Suid-Afrika het om slim stede te bou.

## 1. INTRODUCTION

The 21st century has seen a rapid growth in technology, which has caused the growth of opportunities in urban areas. As these opportunities increase, people move from rural areas to smarter urban environments. This growing trend of urbanisation is happening globally, and will continue in the coming years. Currently 50% of the global population lives in urban areas, and it is forecast to grow to 70% by 2050 [1]. This will lead to an ever-increasing need for urban living, and urban infrastructure will be forced to become more adaptable and agile. The 'smart city' can address a number of the challenges that are inherent in ever-growing urban areas. The effective deployment of technology, and more specifically of the Internet of Things (IoT), seems to be one of the characteristics of effective smart cities.

The purpose of this article is to provide an exploratory literature review of smart cities in South Africa. In the pursuit of this goal, the focus falls first on a brief overview of the evolution of cities, from those of early Mesopotamia to contemporary cities. In section three the focus falls on defining smart cities and exploring their benefits. Section four aims to understand what smart city projects there are around the world. Section five is dedicated to the state of smart city development in South Africa. The article concludes with an overview of the most important challenges and opportunities that stakeholders face in the quest to establish smart cities.

In the next section the focus is on the evolution of cities over the past 10 000 years.

## 2. THE EVOLUTION OF CITIES OVER THE PAST 10 000 YEARS

The first cities originated around 7500 BCE in the historic region of Mesopotamia. Several cities grew in this area between the Euphrates and Tigris Rivers, also known as ‘the fertile crescent’. These cities included Eridu, Uruk, and Ur, and their origins were all related to the fertile land in this area. Such cities normally had their origins in fertile areas and being close to waterways. The fertile areas aided in the success of cultivating crops, and people could give up their nomadic lifestyle of hunting for survival and take advantage of the food surpluses arising from agricultural production; while the waterways provided people with transportation systems to facilitate trading. Cities formed around the world, from the Nile River in Egypt to the Huang River in China and the Indus River Valley on the Indian subcontinent [2].

As the complexity of the trading network increased, the world appeared to shrink within a few hundred years. Rome was the first European city to develop networks that were similar to those of modern global cities. Rome’s empire consisted of a federation of cities that stretched from the Euphrates River in the east to Spain and Scotland in the West. Each of Rome’s cities had a territory attached to it. Amidst the increased movement of people and money, Rome provided the infrastructure and systems to complete these activities. They provided administration systems, political stability, a monetary regime, and tax structures [3].

Commerce began to increase in Europe during the late Middle Ages. This period is also referred to as ‘the commercial revolution’; it was spurred on by countries such as England and Spain, which undertook exploratory voyages and started trading with more distant countries. Other regions, such as Africa, Asia, and the New World, also participated in the commercial revolution by accepting the principles of mercantilism, creating a money economy, increasing economic specialisation, and establishing national banks and stock exchanges. All of these activities of the commercial revolution were a major catalyst of the first industrial revolution [4].

The first industrial revolution, which was characterised by automation and large-scale manufacturing from the late 18th century onwards, led to massive urbanisation and the rise of great new cities, first in Europe and then in other regions, as new opportunities brought huge numbers of migrants from rural communities into urban areas. England led the way: London became the capital of a world empire, and cities across the country grew in locations that were strategic for manufacturing. In the United States, the introduction of railroads from 1860 to 1910 reduced transportation costs, and large manufacturing centres began to emerge, fuelling migration from rural to city areas.

Industrialised cities became deadly places to live because of health problems caused by overcrowding, the occupational hazards of industry, contaminated water and air, and communicable diseases such as typhoid and cholera. Factories and slums emerged as regular features of the urban landscape [5].

However, improvements in medical knowledge and public health, together with a more regular food supply, contributed to a drastic reduction in the death rate; but there was no corresponding decline in the birth rate. The result was a population explosion in Europe during the early parts of the 19th century. The population in London grew from one million people to six million in only ten years. By 1950, the second industrial revolution had caused New York to grow to a population of 12.5 million, making it the largest city in the world [2].

Another great contributor to population growth was the invention and innovation of new technologies. Steel innovations enabled the development of skyscrapers, meaning that buildings could be built upwards, thus increasing population density. The invention of the elevator (the lift) enabled the movement of people within these high buildings. More recently urbanisation has fuelled population growth in cities, creating a new type of city - the megacity. A megacity is defined as a city that has a population of 10 million people or more. Around 1950 New York City and Tokyo, Japan became the first megacities in the world; by 2018, there were no fewer than 37 megacities around the globe [2].

The growth of cities today gives a good indication of what the future might look like. Cities are rapidly growing, as is the number of megacities. The United Nations (UN) predicts that, by the year 2030, there will be 40 megacities. India, which currently has five megacities, is predicted to have seven by 2030. The capital of the Democratic Republic of the Congo, Kinshasa, which has a population of 11.6 million people and so is classified as a megacity, is predicted to surpass some of the world’s largest cities by 2030 [2]. Increased urbanisation and the management of these megacities present various challenges that could be

addressed by embracing the principles and benefits that are inherent in what is referred to as a ‘smart city’. In the next section, the focus falls on the definition, characteristics, and benefits of smart cities.

### **3. SMART CITIES: DEFINITION, CHARACTERISTICS, AND BENEFITS**

In this section the current literature on smart cities is briefly explored. In sub-section 2.1, various definitions of smart cities are presented, and then the focus falls on the general characteristics and inherent benefits of smart cities.

#### **3.1. Definition of a smart city**

The concept of ‘smart cities’ is novel in the context of urban evolution over the past 10 000 years. The first idea of a smart city (or digital city) dates back to 1974, when the city of Los Angeles (LA) introduced an urban big data project. The report, A cluster analysis of Los Angeles, gathered data and developed reports that outlined LA’s demographics in an attempt to reduce poverty [6]. Since this initial report, several theorists and practitioners have attempted to define smart cities. In this section some of these seminal definitions are explored.

Cretu [7] considered two aspects that define a smart city: first, that smart cities should consider the economy and have strong governance; and second, that information and communications technology (ICT) should be integrated into all aspects of society.

In his 2007 report, Smart cities - Ranking of European medium-sized cities, Giffinger [1] chose six characteristics to define smart cities, but did not exclude possible additional factors. According to him, the six characteristics to be considered were smart economy, smart people, smart governance, smart mobility, smart environment, and smart living.

Hamilton et al. [8], in an IBM study, define a smart city as “connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city”.

Nam and Pardo [9] argue that

[a smart city] infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains.

Finally, Lombardi et al. [10] state that smart cities are characterised by the application of ICT along with its effects on human capital/education, social and relational capital, and environmental issues.

As might be seen from the definitions above, the term ‘smart city’ has no single definition; however, a number of core principles overlap all of the definitions.

Smart cities are any type of urban area in which technology is implemented in all of its spheres to improve the living conditions of current and future inhabitants. For the purpose of this article, the six-dimensional theory of Giffinger [1] is adopted as the definition of smart cities, as it gives a distinctive framework with which to design and measure a city.

#### **3.2. Characteristics of smart cities**

The Giffinger [1] six-dimensional theory of a smart city considers smart economy, smart mobility, smart governance, smart environment, smart people, and smart living. In this section each area is explored further.

### **3.2.1. Smart economy**

A smart economy is an environment in which healthy competition between organisations drives innovation. It also allows entrepreneurs to have a platform to build connections and economic wealth. A smart economy should be a highly productive ecosystem that is not slowed down by archaic ideas and business concepts. Finally, a smart economy should have a strong ability to integrate with other economies to allow the economy to grow [1].

### **3.2.2. Smart mobility**

Smart mobility can also be referred to as ‘smart transport’. It is the idea of creating a transport network that connects citizens in a city while considering such other aspects as the environment, the people, and a smart living culture. Smart mobility should not only support the travel of people within the city, but also connect people to communities outside the borders of the smart city. It should also be deeply integrated by ICT, as this would add to the value and effectiveness of the system [1].

### **3.2.3. Smart governance**

Smart governance supports the themes of transparency and integrity. The city should integrate all role players into the decision-making process: government structures, public companies, the private sector, and citizens should play a role in ensuring data integrity [1]. Data governance is also a very important concept that ensures that the availability, usability, and security of data in an ecosystem is governed on the basis of a set of policies and standards that has been set up in the initial stage of development [11].

### **3.2.4. Smart environment**

A smart environment is one of the core concepts that all of the literature notes as a necessity for future cities. A smart city should be smart in how it interacts with waste and water and other natural resources [12]. The idea of a smart environment interacts with all of the other dimensions of a smart city. When planning the mobility and transportation network, one should select options that will keep pollution to a minimum and set out routes that are the most efficient and so use as little energy as possible. In governance, decisions should contribute to a greener society [1]. The people of the city should lead a lifestyle - and be provided with options - that will contribute to an environmentally smart community [13].

### **3.2.5. Smart people**

In a smart and sustainable city, social and human capital occupies a predominant place. The ‘smart people’ dimension refers to a more inclusive society, a community that offers equal treatment to everyone by considering the needs of all in the community. Thus smart cities and the IoT should improve knowledge management and access to education and social capital [13].

### **3.2.6. Smart living**

Finally, smart living highlights one of the fundamental objectives of a smart city: that it should lead to the improvement of its citizens’ quality of life. A smart city should improve health, safety, and social cohesion in the city [13].

## **3.3. Benefits of smart cities**

Smart cities offer many benefit, which include everything from data collection in order to make future-based decisions, conduct proactive analyses, and improve overall service delivery, to economic development, enhanced community engagement, better transport networks, increased safety and security, improved infrastructure and utilities, and a reduced environmental footprint. These benefits are briefly explored in more detail in the next section.

### **3.3.1. Data-based decision-making**

Stronger decision-making is facilitated, and possibilities are created by big data and the IoT. Rujan has [14] noted that this enhances residents' lives, cuts costs, and improves services.

Richards [15] notes that increased availability and value of collected data raises several questions. He distinguished between diagnostic analysis and proactive analysis. Diagnostic analysis refers to those aspects that data systems are currently supporting, and only reports on what has happened in a given scenario, and why. At the other end of the spectrum, proactive analysis refers to instances where the same data is used to analyse not only the past but also the future. Questions are asked to determine what could happen and how people might react and respond to these scenarios; and this analysis is tailored to each user's unique needs and challenges. Operational performance could be optimised, public infrastructure maintenance could be facilitated, and public safety could be prioritised with the correct use of the collected data.

### **3.3.2. Economic development opportunities**

Prasanna [16] is of the opinion that regional and global competitiveness improves where investment in smart cities takes place. Smart cities not only attract new residents, but also improve the businesses within them. Informed decisions can be made when the entire city has access to an open data platform and information; and this leads to economic development.

Woetze et al. [17] explore how the private sector can engage in city development. They conclude that development and design in traditional cities is mostly dominated by the public sector, which locks city councils into capital expenditure with a very long return on investment. In smart cities a much greater onus rests on the private sector to provide traditional public services, such as transport. This outsourcing of responsibilities is an opportunity for economic development in the private sector.

### **3.3.3. Enhanced community engagement**

Smart cities have the potential to enhance engagement in communities. In a report by Woetze et al. [17], they note that it is hard to quantify community. However, they conducted a survey of urban residents to determine whether digital channels and digital platforms used for communication and interactions between local officials and the community could increase the sense of community. The results showed that these digital channels and platforms doubled the number of people who felt a sense of connection between people in the local community, and nearly tripled the number who felt connected with the local government. By maintaining a presence on social networks, or even developing applications for citizens to use, governments are more responsive, residents can more easily report any concerns or problems, and data can be collected to make informed decisions.

### **3.3.4. Better transport networks**

Smart cities can provide new and improved transport networks. In an article published by SmartCity Press [18], the authors discuss an intelligent transportation system (ITS) and how it provides a new approach to how people travel and commute. By using wireless electronics and communication technologies, users and consumers are provided with a "smarter, safer and faster way to [travel]". They also state that market reports had estimated an annual growth rate of 25.1 per cent in the smart transportation segment between 2017 and 2022 [18].

Smart transport systems can drastically reduce commuting times. Woetze et al. [17] predict that, by 2025, cities that adopt intelligent mobility applications can cut the average time of commuting by 15 to 20 per cent, which translates to about 15 to 30 minutes every day.

### **3.3.5. Reduced environmental footprint**

Environmental pressures increase with the growth in population and consumption. Woetze et al. [17] state that technology can be a powerful tool in addressing this environmental pressure. In an analysis by McKinsey, it was shown that technology applications could reduce emissions by 10 to 15 per cent, water consumption by 20 to 30 per cent, and the volume of solid waste per capita by 10 to 20 per cent [17].

Kondepudi [19] argues that a smart sustainable city should be innovative and use ICT and other means to improve the quality of life, the efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations economically, socially, and environmentally. A smart city therefore not only increases the economic opportunities of a community, but also keeps the environmental needs of present and future generations in mind.

### **3.3.6. Improved infrastructure**

Richards [15] notes that predictive analytics, which is one of the many benefits that smart technologies provide, can improve the infrastructure in smart cities. Predictive analytics can provide information on and warnings about the possible failure of infrastructure, providing cities with the opportunity to fix the problem before an actual failure occurs. The smart sensors in these smart cities and technology environments enable the collection and analysis of data to warn people of defects in buildings and to act accordingly. These messages and warnings sent to the personnel informs them either to inspect or to perform maintenance, and in the process significant money is saved on preventable infrastructure failure.

Improved infrastructure by implementing smart sensors in a smart city depends a great deal on the reaction time to the notifications and warnings received. Woetze et al. [17] estimated that, in 2017, the number of IoT devices - over 8.4 billion - exceeded the world's total population, and even more so in 2020, with over 20.4 billion. If used to their full capacity, IoT devices can provide strong communication for a city by transmitting data collected by smartphones and sensors quickly and securely.

### **3.3.7. Safer cities**

Deploying smart technologies can lead to safer cities. Woetze et al. [17] found that smart technologies can reduce fatalities by eight to ten per cent and reduce crime incidents by 30 to 40 per cent, which is equivalent to 300 lives saved per year for a city with five million citizens. Furthermore, they found that emergency response times in cities can be reduced by 20 to 35 per cent by optimising emergency call dispatching and synchronising traffic lights for emergency vehicles.

In 2012, Santa Cruz in California used algorithms to predict crime hotspots in the city. Police officers could be deployed to these locations at the right time in order to prevent crime. It was found that during the first six months of the deployment of this programme, burglaries reduced by 14 per cent and vehicle theft by four per cent [20].

### **3.3.8. Improved utilities**

Smart cities and smart metering in these cities have the potential to improve utilities. Booyesen [21] discusses the potential of smart meters, and how water usage can be reduced by implementing smart metering solutions. Smart meters can remotely record and report the use of electricity, gas, and water. In a case study by Booyesen [21] on a university campus, a local coffee shop's water consumption reduced by 68% in only one week; this was done simply by providing the shop with information about its consumption. Similar studies of homes also illustrated that consumption reduced by between 40 and 60 per cent. In Booyesen's studies, the biggest impact of the smart metering was seen in the case studies implemented at schools. On average, 16 kilolitres per school per day were noted at three of the schools. During the school holidays, one school was able to prevent a loss of around one million litres of water when a pipe burst by being notified through smart metering that an excessive amount of water was being consumed.

In the next section, the nature and characteristics of a few world-class smart cities are briefly presented.

## **4. SMART CITIES AROUND THE WORLD**

Woetze et al. [17] report that New York, Los Angeles, London, Seoul, Singapore, and San Francisco are the cities with the highest number of smart technology applications. Their solutions have also branched out into more than one domain. In this article, the focus is on San Francisco, London, and Singapore.

The IESE Business School [22] developed the Cities in Motion (CIM) index as a smart city ranking method, to rank cities objectively on the basis of 10 key dimensions: governance, urban planning, public management, technology, the environment, international outreach, social cohesion, mobility and transport, human capital, and the economy. London ranked first, Singapore ninth, and San Francisco 21st [22].

#### 4.1. San Francisco

Cities in the United States of America have pioneered smart cities since the idea's inception in the 1970s. In 2012, San Francisco (SF) was named the greenest city in North America [23].

SF, which was ranked 21st on the CIM index, has been part of the international network of smart cities since 2011 [24]. An article by the Municipal Transport Agency [24], Meeting the smart city challenge, discusses the implementation of smart technology in SF, which uses smart transportation, energy, and community to serve its citizens. These smart solutions provide many benefits to the city, including improving the operational performance of buildings, extending transportation systems, reducing the use of energy, and centralising waste management systems. According to the Municipal Transport Agency [24], the award of greenest city in North America that SF received in 2012 was mainly because of the waste management system that it had implemented.

The Municipal Transport Agency [24] also noted that SF had set many goals that contributed to its smart city status. Among these were to have zero waste by 2020 and to reduce greenhouse gas emissions (as noted in 1990) by 25 per cent by 2017.

In an article entitled Designing a smarter, more sustainable San Francisco, the San Francisco Environment Department [23] explains that, in 2009, the former mayor of SF, Gavin Newsom, introduced the first open data legislation, which required city departments such as the Police Department, the Public Utilities Commission, the Department of Public Works, and the Municipal Transportation Agency to make non-confidential datasets available on DataSF, the city's website for government data [23]. According to [23], this made over 200 datasets available, and over 60 software applications were created from the data that was published and shared. [23] also states that SF offers next generation payment systems to its citizens, thus making smart solutions available to all. According to Woetze et al. [17], SF is one of a few cities that have implemented many security and safety applications, making the city smart and safe for all of its citizens.

#### 4.2. London

In Imagining the future city: London 2062, Bell and Paskins [25] describe London as a city that is "both ancient and modern", with a concentration of different types of people, religions, languages, political power, and ideas. They go on to describe London as highly innovative in the fields of technology, finance, art, and education, which are rooted in and reflect its 2 000 years of history. The IESE Business School [22] believes that it is for these reasons that London has deserved its top position in the CIM ranking for the years 2013 to 2015.

The IESE Business School [22] report notes that London leads the rankings of three of the key dimensions used in the CIM ranking method: human capital, public sector management, and international outreach. In respect of human capital, London is the city with the highest number of universities and business schools, and a large part of the population has been through secondary and higher education. With reference to public sector management, London has the highest number of airline passengers, as well as the most airline routes.

The IESE Business School [22] report also ranks London in one of the top positions in the economy dimension of the CIM ranking. According to Bell and Paskins [25], London's strengths lie in its wide range of opportunities, making the city an attractive space for conducting business.

#### 4.3. Singapore

Singapore is an island state located in Southeast Asia. The city has no natural resources. The global economic shift from an industrial economy to an information economy gave Singapore the opportunity to enter the world stage. According to Mahizhnan [26], Singapore has embraced the use of information

technology [26], which is why its government has defined the future of Singapore as ‘an intelligent island’, and has started to build up the necessary infrastructure to support this future [26]. Given its lack of natural resources, Singapore has been forced to adopt the principles of smart city living.

Singapore ranks ninth on IESE’s overall CIM index [22]. According to the IESE Business School [22], it rank shigh in the dimensions of governance, economy, and international outreach, but specifically stand out in the technology dimension [22]. Woetze et al. [17] note that Singapore was one of the first places to provide free Wi-Fi across the country, which enabled them to provide “cutting-edge communication networks”.

In respect of mobility, Woetze et al. [17] note that self-driving taxis have already been implemented in Singapore. It is committed to innovation and mobility, and is busy deploying extensive resources to implement the use of autonomous cars and buses.

## **5. SMART CITIES IN SOUTH AFRICA**

In his 2019 state of the nation address, South African President Cyril Ramaphosa spoke about a new type of city in South Africa. He described a smart city powered by IoT devices and smart technology, and in 2021 he introduced three new developments aiming to become examples of South African smart cities: Lanseria, Durban Aerotropolis, and Mooikloof Mega-City. Since the introduction of these ambitious projects, very little progress has been made towards their establishment.

Fataar [27] is sceptical in his analysis, arguing that South Africa lacks an integrated national smart city strategy; that the existing smart city initiatives are uncoordinated; and that the private and public sectors are not jointly pursuing the goals of establishing thriving South African smart cities.

Despite the apparent absence of a well-coordinated smart city strategy, there are some examples where both the private and the public sector have been able to rise to the occasion. Waterfall City in Gauteng seems to be one of these. Balkaran [28] describes Waterfall City as the “the largest mixed-use development in South Africa”. It gives the community the possibility of enjoying the convenience of work, life, and lifestyle all in one environment. With its close proximity to the Mall of Africa, residents have an abundance of shopping choices.

The City of Cape Town showed the willingness and ability to employ technology to overcome severe challenges during the 2018 drought. This extreme drought was a catalyst for smart water management. The city council and residents were forced to find better ways to manage their water usage as Day Zero appeared on the horizon. The city management introduced smart utility technology, using smart remote meters to measure and manage strategic points. Sokolowski [29] found that the use of these smart technologies enabled the city council to reduce water use by 10%.

## **6. SMART CITIES: CHALLENGES AND OPPORTUNITIES IN SOUTH AFRICA**

The advantages presented by the creation of smart cities are obvious, yet their establishment in the South African context is not without difficulties. In this section the focus falls on some of the challenges that South Africa and other developing countries will need to overcome in their quest to develop smart cities.

### **6.1. Challenges**

Aghimien [30] argues that high urbanisation, increased population growth, poor basic infrastructure, poverty, poor legislation and regulations, economic instability, and poor governance are some of the factors preventing the establishment of smart cities in Africa. Rana et al. [31] have found ineffective governance to be the biggest stumbling block in developing countries. These challenges are explored in more detail in this section.

#### **6.1.1. Poor governance**

The Oxford Dictionary defines governance as “the activity of governing a country or controlling a company or an organization” [32]. Introducing new smart city projects potentially creates extra need for good governance, which has not been a strong suit of the South African government in recent years. Political instability, city networks operating in silos, lack of an ICT vision, and a lack of trust between parties about

sharing data are all governance problems that Rana et al. [31] found to be a hurdle in smart city development in developing countries. Unfortunately, South Africa is no exception to the rule, and it currently faces serious governance issues at all levels of government.

#### **6.1.2. *Poor regulation and corruption***

The next governance challenge is regulation and corruption, with polarising concepts and the lack of implementation of regulations leading to corruption. With data and data-sharing being a large component in smart cities, it is vital that strong policies and regulations are put in place to protect citizens' private information. South Africa's history of corruption could pose a threat to data security, which in turn would result in a lack of trust between the private and public sectors.

#### **6.1.3. *Poor basic infrastructure***

Another major problem that South Africa will have to overcome is the lack of infrastructure after years of neglect [35]. Rana et al. [31] note that a lack of technological knowledge among city planners and a failure to maintain the current infrastructure are problems that any government that aims to develop smart cities will need to solve. It is no secret that the cost involved with smart city development is extremely high; but if a city wants to become smart, it should not only account for the present, but should also consider how it will meet the maintenance costs of the technology that it implements [33].

#### **6.1.4. *High urban density and increasing informal living***

The high rate of urbanisation has led to an increase in informal settlements in and around South Africa's metropolitan areas. Johannesburg and Cape Town are home to many informal settlements, or 'townships' as they are known locally. Deloitte Touche [35] notes that the rapid urbanisation places additional strain on housing and transportation networks. Smart city development will be faced with the challenge of planning not only for the demands of the current population but also for future demands. Another consequence of rapid urbanisation is that insufficient sewerage and waste management is in place [33]. This is a critical environmental issue that smart city developers will need to manage in future developments - and solve in the current environment.

### **6.2. Opportunities and future trends**

Although South Africa is faced with many challenges, as noted above, the introduction of smart city projects brings South Africa a host of opportunities for growth. A 2019 report by PwC lists several future trends that smart cities will enable, including artificial intelligence, smart grids, improved security and privacy, green initiatives, data being used for community engagement, and an increased number of smart buildings [36]. According to Bohloul [37], there will be a greater need for smart tools, and that this will create new business opportunities. The main areas he identifies are hardware and software applications, the security and privacy sector, and the education sector (to enable a new generation to interact with these new technologies). In the South African context, four of the most important sectors will be economic development, new education streams, integration of society, and new financial services. The new smart technologies that are being developed will create opportunities for young and ambitious entrepreneurs to pursue.

## **7. CONCLUSION**

The high rate of urbanisation and the increasing need for more sustainable living create the perfect conditions for the development of smart cities. For smart cities to be successful and efficient, governments will have to develop a strong presence in ICT and increase the use of IoT devices. The evolution of cities throughout history has made it clear that the development of new technology is the biggest driver of change in how we live and interact. And with the ever-increasing environmental pressure the world faces, the development of smart cities will need to increase to meet this challenge.

This article has explored the literature to define better what a smart city is, and has found that most definitions have the same core principles. Smart cities are any type of urban area in which technology is implemented at various levels to improve the living conditions of their current inhabitants and to ensure the same for the future. The six-dimensional theory of a smart city by Giffinger [1] was used as the

evaluation framework for the purpose of this study. It also found several benefits that result from the development of smart cities: better data-based decision-making, more economic development opportunities, enhanced community engagement, better transport networks, a reduced environmental footprint, improved infrastructure, safer cities, and improved utilities management.

The research explored smart city projects around the world to identify which elements the South African government should incorporate into its future smart city plans. Smart city projects in South Africa seem to be very few and far between, as there is no integrated national smart city strategy [27]. Finally, the challenges and future growth opportunities in a South African context were explored. Although South Africa and other developing countries are faced with a host of difficulties, smart city development will create an abundance of new opportunities for economic growth, new developments in education, greater citizen integration, and exciting new financial services.

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