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Access to Technology and Data in Smart Cities for South African Digital Citizens

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ABSTRACT

Lack of access to technologies and quality data are key challenges for reducing the digital divide and developing digital citizens to support Smart City initiatives. This paper reviews efforts towards Smart Cities and access to smart technology and Open Data in developed economies globally and in South Africa. Reviews of literature and websites were conducted and the Qualitative Content Analysis method was used to analyse the data. The contributions are the commonalities and differences between Smart City initiatives in developed economies and in South Africa. The findings revealed that in developed countries the focus was mainly on e-services, citizen engagement, Intelligent Transport Systems and energy systems. They provided city-wide connectivity and addressed integration and interoperability challenges. The technologies included large IoT sensors and WiFi in-motion networks incorporating internationally accepted standards. Initiatives in South Africa were less mature, mostly in the initial stages and are not addressing other more urgent needs of the country such as water, food, shelter and education. Collaboration with best practice Smart Cities is needed to provide support to current and future initiatives in South Africa and for the development of African digital citizens.

Keywords

Smart Cities, Open Data, Data sharing, Data privacy, Data portals, Data policy

INTRODUCTION

The post-COVID society in which we live is vastly different to that of even a decade ago. The global state of society is a digital one, which has necessitated the need to deeply change the way health and other critical information will be managed in this century (Costa & Peixoto, 2020). More coordinated actions from governments and public

organisations are required and Smart Cities can be leveraged as a resource to beat this and future pandemics. One definition of a Smart City describes it as including information flow in an intelligent way to translate into more resource efficient citizen services (Albino et al., 2015). Information flow is dependent on citizens having access to quality data sources in the city so that societies can be connected and services can be provided (Yadav et al., 2017), and is made possible through Information Communication Technology (ICT) and smart technologies such as the Internet of Things (IoT), cloud computing and Artificial Intelligence (AI) (Allam & Dhunny, 2019; Lu et al., 2019). However, access to data and smart technologies are constrained in emerging economies such as South Africa due to the digital divide, which refers to the gaps in access to ICTs between the ICT 'haves' and the 'have-nots' and keeps billions of people offline (ITU and Orbicon, 2022). The high percentage of technologically unskilled citizens in South Africa impacts the development of digital citizens (Bennett, 2018). A digital citizen is described as one who "*uses the internet regularly and effectively*" or as a person using information technology (IT) for the purpose of engaging with other citizens in society, in politics, and in government (Mossberger et al., 2008). To close the digital divide, Open Data platforms are crucial. Yadav et al. (2017) state that Open Data is needed for creating Smart City solutions, since access to public information is a fundamental right for citizens and leads to improved decision making and service delivery. Lea & Blackstock (2014) argue that if a city's IoT technology can be combined with access to Open Data then developers can focus on integrating disparate data sources and on developing smart applications to meet the needs and opportunities of cities and optimise services to stakeholders.

South Africa has announced the launch of several Smart City initiatives (Mzekandaba, 2021). However, Nalla (2021) argues that before these initiatives can be successful, South Africa should first meet the needs in the lower tiers of Maslow's hierarchy, such as water, food and shelter, after which they can aspire to the heightened aims of the rest of the world. According to Nalla (2021), the key element of a Smart City is the increase in efficiency and quality of citizen services, and that it is *"fortuitous that the time of the 'Smart City' coincides with the deepest pressing need to rebuild South African urban centres".* Nalla (2021) also states that South African citizens face more challenges than those of developed countries, such as apartheid-embedded inequality, high unemployment rates, poverty and corruption. The majority of citizens are therefore not able to access resources such as equal education, housing and utilities.

Whilst Smart City research has increased exponentially in the last decade, evidence of solutions and initiatives are primarily from developed countries. Research into actual initiatives in emerging economies such as South Africa, and the purpose and value of technologies and Open Data used for these initiatives are still limited (Silva et al., 2018;Van Der Hoogen, 2021). The purpose of this paper is to address this gap and meet the research objective '*To analyse and classify existing data and technological initiatives for Smart Cities in developed countries and compare these initiatives with those in South Africa'*. A literature review was conducted to understand the theoretical context, the latest trends in Open Data and Smart City research, and to identify real-world initiatives globally and in South

Africa. The findings of the literature review identified very few cases in South Africa, therefore a review of websites was conducted. The Qualitative Content Analysis (QCA) approach of Schreier (2013) was used to analyse the data. The research contribution is a set of themes and categories related to the cities, technologies and purposes of Smart City initiatives in developed countries within the European Union (EU), Asia and the United Kingdom (UK) as compared with those in South Africa. The structure of the paper is as follows: The next section provides an overview of the research objectives and adopted methods, which is followed by a summary of the literature review conducted on Smart Cities and Open Data policies. The findings of a rigorous literature review conducted on global and South African initiatives for Open Data and Smart Cities are then described in the following section. Next, a discussion of the findings is presented. The last section concludes the paper and provides an agenda for possible future research.

RESEARCH OBJECTIVES AND METHODS

The following sub-objectives were used to address the main research objective:

RO1: To analyse technological initiatives in Smart Cities globally.
RO2.1: To identify and classify the purpose of and technologies used in South African Smart City initiatives.
RO2.2: To identify and classify South African Open Data initiatives.

For RO1, a literature review was conducted using the systematic process based on the Centre for Reviews and Dissemination (CRD) method (CRD, 2009), which is used as a practical guide to provide high standards in conducting reviews. The six steps from CRD were followed. The first step was to identify the review questions/objectives for the search, in this case RO1. The second step was to specify the inclusion and exclusion criteria and the process followed. The first set of inclusion criteria was the search term "*Technologies for Smart Cities*" using the Web of Science (WoS) database for journal articles, reviews and editorials in the fields of Computer Science, Engineering and Telecommunications. Only one search term was used since the requirements were specific and narrow. The selected date range was for the last ten years i.e. those published from 2009 to 2019. Articles from all countries were considered. The search resulted in the return of 51 documents. The list was refined to return only the journal articles, and because of this refinement 21 articles remained. In the third step studies were selected as part of the final list for review; here each of the 21 articles was analysed to identify IoT and data initiatives in the Smart City context. The fourth step was identification of the research evidence, where the 21 articles were further analysed to identify whether they included actual case studies of technological initiatives in the Smart City context. Only four articles met the criteria, none of which were in the context of South Africa. In Step 5, the synthesis of the data and keywords was conducted on the four articles and in Step 6 the data was extracted from the studies. In Step 7 the main analysis took place to analyse technological initiatives in Smart Cities globally according to the country, purpose of the initiatives and the technologies used. The QCA approach of Schreier (2013)

was adopted whereby the coding frame was built by structuring and generating themes; defining the themes; and revising and expanding the frame until saturation was reached. Segmentation and trial coding took place and then the coding frame was evaluated and modified. The term Smart Mobility was used as the theme for all initiatives related to transport, traffic and other mobility projects, whereas Smart Energy was used as the theme for all initiatives related to reducing energy consumption, such as solar energy. A summary of the initiatives and main themes is provided in Appendix A. The last step of the CRD was dissemination of the data, which took place through the publishing of this article.

For RO2, the first sub-objective RO2.1 was addressed simultaneously with RO1 through the CRD. For RO2.2 an exploratory literature review was conducted with the search terms: *"Open data* AND *"South Africa",* for the last five years, 2017 to 2021. Neither of these reviews identified any relevant academic articles that met the criteria. Therefore, a web search was conducted in March 2022 using the same search terms but in the Google search engine. A manual review of the information presented on the relevant websites was then conducted,

BACKGROUND AND LITERATURE REVIEW

Smart City research is rapidly increasing in popularity. Some studies on Smart Cities have proposed various definitions (Albino et al., 2015), Big Data models (Allam & Dhunny, 2019), and frameworks with dimensions of Smart Cities (Sujata et al., 2016; van der Hoogen, Scholtz and Calitz, 2019). Other studies have focused on the opportunities and benefits of Smart Cities and Open Data for citizen engagement and service efficiency (Ricker et al., 2020; Santana et al., 2018) and to tackle crises in the city such as health (Costa & Peixoto, 2020). Open Data is seen as a key part of a Smart City together with related policies and regulations (Ojo et al., 2015; Van Der Hoogen, 2021). Some authors have focused on the more technical challenges that are introduced with Smart Cities and achieving Open Data, such as designing appropriate architectures (Silva et al., 2018) or approaches to addressing the challenges related to standardised and secure data formats and sources needed for analysis purposes (Santana et al., 2018; Tucker et al., 2017).

A study of Open Data in African countries was conducted by Bello et al. (2016) who argue that public sector data should be open so that citizens can hold their government accountable for not meeting their stated goals. A study conducted in Cape Town, South Africa, reported on the drive for engagement with municipal Open Data by local civil society organisations (Ricker et al., 2020). This drive has been referred to as data-driven activism. The authors argue that cities should adopt the philosophy of data openness, which encourages civic participation with Open Data. In Europe, to achieve an effective Big Data ecosystem with its related benefits, the societal and environmental goals of "*reducing fragmentation of languages, intellectual property rights, laws, and policy practices between EU countries*" need to be attained (Curry, 2016). In the United States of America (USA), the Committee on Geophysical

and Environmental Data, as part of the National Research Council in Washington, DC, was one of the first organisations to introduce the term Open Data (National Research Council, 1995). The committee's goal was to provide an open and full exchange of scientific data, specifically geophysical and environmental data, between countries. The advantage of this exchange is that it addresses worldwide issues in a more integrated, cost-effective and efficient manner than having to perform these tasks independently. One of the leading Open Data portal platforms is CKAN (Comprehensive Knowledge Archive Network), which has been adopted by national and regional governmental organisations throughout the EU, USA, Asia and Oceania (Yadav et al., 2017). The CKAN system makes data accessible by providing powerful data management facilities and tools for streamlining publishing, sharing, finding and using data for official and community data portals (CKAN, 2017). Kassen (2017) explains that Open Data is a "*phenomenon"* that contains datasets available as raw material with no copyright restrictions for further processing and reuse.

In the EU, the Open Data Maturity (ODM) Report measures the maturity of Open Data in European countries using a set of indicators across four dimensions of policy, impact, portal and quality (Van Hesteren & van Knippenberg, 2020). In the 2021 ODM Report the average ODM score of the 27 EU countries was 81%, an increase of 3% compared to the previous year. France was the leading country overall with 97.5%, followed by Ireland, Spain, Poland, Estonia and Ukraine. From the ODM portal, users can download datasets such as France's COVID-19 vaccination data and Ireland's water level data. Estonia was mentioned for the first time in this report as a "trendsetter" country. Overall, countries scored the lowest for the quality dimension, which evaluates the extent to which national portals have a systematic and automated approach to data harvesting, the currency and reliability of metadata, as well as the level of compliance with the Data Catalogue vocabulary (DCAT) Application Profile metadata standard. This standard is based on W3C's DCAT for describing public sector datasets in Europe, which is used to improve the searchability and exchange of public sector data across borders and sectors.

While Open Data is a sought-after ideal, it must be balanced with the rights of data privacy and protection of data of all citizens. In Europe, the major information policy, namely the General Data Protection Regulation (GDPR), was updated in 2018 (GDPR, 2018), with three main objectives related to personal data of natural persons as follows: the rules regarding movement, protection rights and processing of the data. Similarly in South Africa, the Protection of Personal Information Act (POPIA) was implemented to *"promote the protection of personal information processed by public and private bodies"* (POPIA, 2020).

The exploratory background literature review confirmed the need for this research since the majority of studies related to Smart Cities and Open Data initiatives were conducted in developed countries. Very few articles were in the context of Africa, and even less in South Africa and these were not related to empirical cases or standards for Open Data or technological initiatives. Without an understanding of these initiatives, access to technology and data and ultimately digital citizenship data will still be denied to the majority of citizens in South Africa.

FINDINGS

Technological Initiatives in Smart Cities Globally

The first article (Yaqoob et al., 2017) reported four cases where ICTs were used to enable the Smart Cities of Barcelona, Porto, Stratford and Singapore. Barcelona is well known for being a Smart City and Spain is rated highly in terms of impact in the ODM Report. In this city, ICT is used to accelerate the different sectors by automating processes and identities, and is centered around three pillars of digital empowerment, transformation and innovation. The smart technologies used included 3G/4G technologies, WiFi mesh networks, sensor networks, a public WiFi network, heating and cooling systems, and energy networks. Underground galleries and a mobility plan were also implemented. Porto in Portugal created a connected Smart City by adopting existing infrastructure such as fibre and WiFi to build Intelligent Transport Systems that connected their public transportation system to one of the largest WiFi-in-motion networks in the world using a multi-network OnBoard Unit equipped with WiFi/DSRC/cellular interfaces called NetRider. The city of Stratford in the UK focused on smart metering initiatives and economic growth (Yaqoob et al., 2017). Some of the technologies implemented were Motorola's 802.11n mesh wide area network, the Motorola AP 7181 802.11n outdoor access point and the GPON AXS1800 system (encrypted smart meter data). The meters were installed in 200 homes with 40 access points. The monitoring of electricity usage could be remotely accessed by companies who were stakeholders in the project. The Singapore Smart City is internationally recognised and arose from the lack of natural resources and problems regarding transport, traffic and mobility. Its wireless ultra-high-speed 1Gb/s nationwide broadband was used as the infrastructure and the city's taxicabs used GPS devices and network sensors. The impact of these initiatives was improved traffic monitoring, predictions and route planning.

The second article (D'Aquin et al., 2015) reported on initiatives in Milton Keynes (MK), one of the fastest growing cities in the UK, which has received several Smart City awards between 2014 and 2017. The MK:Smart vision includes initiatives on transport, energy, water, enterprise and citizen education and aims to enable data integration in a data management and usage hub. The technologies used for the data hub were linked data and Semantic Web technologies. Linked data technologies enable *"data integration into a common browsable and accessible graph, while leaving data distributed and managed in different systems, under the control of different contributors*". The key feature of this initiative is that the architecture caters for unknown future applications. Semantic Web technologies use linked data to apply meaningful data models in the form of shared web vocabularies and ontologies to improve interoperability and data analysis. An example of this application (app) is where input provided by an elderly citizen led to the creation of a navigation system in a shopping mall for visually-impaired citizens (Motta, 2017). The MK:Smart project concluded in 2017, but its website states that a follow-up project is being investigated.

Another initiative is Hypercat (www.hypercat.io), whose goal was interoperability between data hubs in different domains. Here, standards for IoT and standards such as HTTPS and JSON were implemented.

The third article reported on several Smart City case studies in the EU that addressed challenges of Smart Cities by developing novel solutions such as open-platform initiatives (Santana et al., 2018). Some of these solutions were launched under the Future Internet and Research Experimentation (FIRE) project, which has funded approximately 87 projects for experimental research of Smart Cities in Europe. Three important projects providing IoT testbeds are *SmartSantander*, *City of Things* and *Bristol is Open*. The *SmartSantander* testbed provides a large-scale IoT sensor deployment in the city of Santander, Spain, and aims to provide large amounts of data from diverse sources to create new services for its citizens. The project has deployed more than 12000 environmental sensors for building facades and lamp posts, for irrigation, for mobile sensors in the public transportation network, and for parking monitoring and traffic entrances/exits in the city. The *City of Things* testbed implemented in Antwerp, Belgium aims to provide a city-wide living lab that allows for citizen engagement and feedback about novel applications and services. It uses a similar network approach to that of Santander. The last project, *Bristol is Open*, is not part of FIRE but has similar aims. Its Smart City infrastructure covers the centre of Bristol in the UK and includes a 144-fibre core network containing four active nodes and full optical switching, a wireless network, an IoT testbed with a fibre-connected lamp post cluster, 1500 sensors, and cloud infrastructure. The testbed provides experimentation support in a real-time environment and supports the HyperCat standard. The fourth article reported on the implementation of an air quality data monitoring system in China universities to address air pollution health risk issues (Hu et al., 2019). The system used a four-layer architecture with technologies such as ground sensing devices, an Unmanned Aerial Vehicle (UAV), cloud storage and a WeChat official account.

Smart City Initiatives in South Africa

The web search identified several sites that presented cases of Smart City initiatives in South Africa. These cases are summarised in Table 1 with the theme and category allocated during the QCA. The Open Data initiatives from the previous section and WiFi initiatives are not included in the table as these initiatives are more generic and not city specific. The provision of free WiFi in major cities in the provinces of the Eastern Cape, Western Cape, Gauteng and Free State was one of the first of its kind and was provided by the South African Local Government Association (SALGA) in 2015 (ITWeb, 2016). This initiative shows efforts by the government to deliver services and to add to "*a robust information society and knowledge economy that is both inclusive and prosperous*". A more recent initiative is *Think WiFi*, a non-profit organisation that has built more than 200 free wireless Internet sites in underserviced communities in the Western Cape, Eastern Cape, Gauteng, KwaZulu-Natal (KZN) and Mpumalanga (Vuk'uzenzele, 2021).

South Africa's President Cyril Ramaphosa, in his 2022 State of the Nation Address, declared that his Smart City dream has become a 'reality in the making' with the launch of the Lanseria Smart City (Mzekandaba, 2021). The aim is to create the first post-apartheid city in the democratic, emerging economy of South Africa based on 'best practice' in urban sustainability and the principles underpinning a Smart City. The main initiatives of this Smart City are 5G-readiness and green infrastructure projects, which are believed to be leading benchmarks at both a national and international level. Another project for the city is the rollout of an e-visa project that aims to encourage investments in critical growth sectors such as tourism. In the same province, the Melrose Arch is a Smart City that boasts safety and innovation with 24-hour closed-circuit television (CCTV) surveillance, a fibre optic network, green-star-rated buildings, onsite power backup facilities and a mobile-enabled payment parking app (Melrose Arch, 2020). The Mooikloof Mega-City development is a new Smart City being built east of Pretoria in Gauteng (BusinessTech, 2021).

A Smart City promised for the KZN province is the Durban Aerotropolis, which aims to become a premier business and trade hub in Sub-Saharan Africa and to convert the whole area around King Shaka International Airport into a Smart City with *"diversified economic activities that will boost the province's economy"*. In the Limpopo province, the Nkuna Smart City Project is underway and, unlike other Smart City developments in South Africa, it may be the first to be initiated by a black entrepreneur without any foreign investment (ConstructionReview, 2021). On a broad scale, the South African National Roads Agency Limited (SANRAL) announced the launch of their Intelligent Traffic (i-Traffic) Management System in 2012 in Gauteng, KZN and the Western Cape (SANRAL, 2012). i-Traffic is a type of Location-Based Service (LBS) that provides motorists with web access to real-time traffic information such as road conditions, incidents, roadworks and weather forecasts (Usman et al., 2018). The Gautrain app, a web-based service in a mobile app, is used for the commuter rail integrated transport system that connects locations between Johannesburg, Pretoria, Ekurhuleni and OR Tambo International Airport (Gautrain, 2020). The app provides access to all the trip planner information, fares, schedules and payment options, and integrates the Gautrain and the Gautrain-bus services.

City/ Province	**Initiative**	**Purpose: Theme (Category)**	**Technologies**
Lanseria, Gauteng	Smart City	Economy; 4IR education; e-services (e-Visas) Smart Energy (solar energy)	5G; e-visas; solar energy
Melrose Arch, Gauteng	Smart City	Smart Mobility; Crime monitoring; Green buildings	Closed-circuit television; fibre optic network, mobile payment

City/ Province	Initiative	Purpose: Theme (Category)	Technologies
Mooikloof, Gauteng	Smart City	Housing; Economy	Unknown
Nkuna, Limpopo	Smart City	Economy	Unknown
Durban, KZN	Smart City	Smart Mobility	Connectivity; Location Based Services
Gauteng; KZN; Western Cape	i-Traffic	Smart Mobility (Traffic monitoring)	CCTV; VMS; fibre-optic network; Location Based Services
Pretoria & Johannesburg, Gauteng	Gautrain App	Smart Mobility	Web-based
Cape Town, Western Cape	Parkfind	Smart Mobility (Navigation and parking payment app)	Location Based Services and Global Positioning Systems
	MyCiti App	Smart Mobility	Mobile app; Location Based Services
	ShotSpotter	Crime monitoring	Surveillance videos; Acoustic technology
	Strategic Surveillance Unit	Crime monitoring	Closed-circuit television
Stellenbosch, Western Cape & Tshwane, Mpumalanga	Namola	Crime & medical monitoring	Mobile
NMB, Eastern Cape	NMBM App	e-Services	Mobile/online systems
	Nelson Mandela University Solar Farm	Smart Energy (Solar Energy)	Solar panels
	Joe Slovo West township school	Recycling	Recyclable building materials
Buffalo City, Eastern Cape	BCMM Smart Meters	Smart Energy	Smart Meters
	Buffalo City Citizen Engagement App	e-Services	Mobile App
	Designer Lighting App	Fault reporting lights	Mobile App

Table 1. The Purpose and Technologies of Smart City Initiatives in South Africa

In Cape Town, an integrated network Bus Rapid Transit (BRT) system, the MyCiti web-based service, was launched for its citizens (MyCiti, 2020). The system was created to encourage social and spatial equality while using CCTV cameras and lighting at enclosed bus stations, to promote a safer city. The service allows for effective trip planning

and to load money on the Myconnect card, which can be tapped for payment when using bus transport. The Parkfind mobile app assists Cape Town motorists with finding and paying for parking in the city (Parkfind, 2017).

A gunshot detection system, also known as ShotSpotter intelligent technology, was implemented in Cape Town and uses CCTV capabilities to identify and track shooters, the shots fired and incident locations (Githahu, 2021). After initial success, ShotSpotter was accused of missing the mark and wasting 32 million rand. During its implementation only 6688 incidents were logged and only 67 arrests were made. The project was abandoned in 2019. Another slightly more successful crime monitoring initiative is that of the Strategic Surveillance Unit of the Cape Town Metro Police Department that monitors over 560 cameras in Cape Town 24 hours a day, 7 days a week (*Western Cape Government*, n.d.). The Namola App is a smaller private crime-monitoring initiative for families and provides emergency response facilities at a crime scene or endangered situation. Alerts are sent to the closest police station for response. It was launched in some of the major cities in the Western Cape, including Stellenbosch, and in the city of Tshwane in Gauteng (Namola, 2017). The app is available to all South African citizens, however, it is a paid service, so it is not freely available to citizens.

The Nelson Mandela Bay (NMB) Smart City initiative was planned as a partnership approach to address the economic challenges in the city, but was suspended due to lack of funding (Regional Innovation Forum, 2018). Some initiatives by the NMB Municipality have launched applications to assist residents with services such as pre-paid electricity purchases, utility statement requests, utility bill payments, incident reporting and meter readings (NMBM App, 2020). The Nelson Mandela University launched its Solar Energy Farm project in 2019, which has helped the university reduce its electricity peak demand by approximately 40% (Rogers, 2019). Smaller initiatives in NMB have made a slow but positive impact in the area. KaziBantu, meaning “active people”, is a project funded by UNESCO to help school children from disadvantaged communities around NMB to improve their health and become more active (Steinmann, 2017). The project aims to reach more schools in South Africa.

A project in the Joe Slovo West township of NMB was initiated by an architect who built a school from only recyclable materials and educates citizens about recycling materials that can be used for buildings (Beamon, 2020). In the Buffalo City Metropolitan (BCM) area, the BCM Municipality (BCMM) Citizen Engagement App was launched to digitise municipal services and enable online payments of municipal bills. According to Dumana (2022), the app had a 5-star rating on the Google Play store and had positive reviews. The impact was reduced operational costs, stimulated revenue, and reduced queuing for citizens. However, at the time of writing this paper, the analysis revealed that the app reviews were all negative, there were several complaints that it does not work, and the website home page had problems with their punctuation in their content pages. Another BCMM initiative was to implement smart meters around the city for consumers to gain access to billing records and to monitor electricity use (Hashe, 2021). However, citizens protested against this system and complained that it was problematic, that electricity could not be loaded due to lack of signal, and that loaded electricity no longer lasted.

The Designer Lighting App was implemented for BCMM citizens to report faults of street, traffic and unmapped lights, and to track the status of these faults (Groove IS, 2020). At the time of writing, the system was still available on the Google Play Store and had mixed reviews.

Open Data Initiatives in South Africa

In Cape Town, South Africa, an Open Data portal was launched based on its Open Data Policy, which aims *"to strengthen Open Data in the City and the dissemination of data through the Open Data Portal"* (City of Cape Town, 2022). It also *"supports the constitutional imperative of Section 32(1)(a) of the Constitution of the Republic of South Africa, 1996 that everyone has the right of access to any information held by the state".* The portal was developed with the goals of stakeholder participation in government and increased transparency. Some of the popular datasets are tender awards, electricity and water consumption, parking, and health. The web site analysis revealed that the data on the site was mostly recent and could easily be visualised and downloaded into CSV or JSON files. It is a beneficial initiative and serves the needs of citizens to access data. However, the datasets are far from comprehensive. The South Africa Data Portal professes to provide Open Data, statistics and visualisations on employment and the labour force in South Africa per province (*South Africa Data Portal*, n.d.). However, the website analysis revealed that the data is outdated, since the latest data seems to be from 2017, and this is only in a few cases and the rest is even older, for example from 2011, 2009 and even 2008. More promising is the openAFRICA platform, which states that its aim is *"to be the largest independent repository of Open Data on the African continent"* (*South Africa - OpenAFRICA*, n.d.). It is a non-government-driven platform, and it is maintained as a free service to the public by Code for Africa. On closer inspection, the platform appears to provide recent datasets from several African countries, including South Africa, Nigeria and Tanzania. Some datasets included are those on access to water and health surveys. OpenUp is another data portal that was analysed (*Openup*, n.d.), which has 206 datasets and while some were outdated others were more recent. For example, there were some datasets on the 2021 elections and air quality. A portal with more up to date datasets is that of UCT's DataFirst project, which has been quite successful and offers 368 South African datasets (*DataFirst*, n.d.). Most of this data is provided in XML or JSON format and relates to labour force, marriages/divorces, crime, and the elections.

DISCUSSION AND IMPLICATIONS FOR SOUTH AFRICA

The findings of the CRD confirmed the scarcity of literature related to Smart City technologies and Open Data initiatives in South Africa. It also highlighted the strengths and best practices in developed countries. The contribution of this paper is therefore significant in that it provides new insights into the status and maturity of actual cases and initiatives that provide access to Open Data and Smart City technologies relevant to South African digital citizens. At a policy level, in both Europe and South Africa the open flow and sharing of information for the benefit of citizens is encouraged with the policies of the GDPR and POPIA, whilst still providing governance,

safeguarding and privacy of data. However, with regard to maturity of Open Data, standards and rating reports such as the ODM were only found in Europe. For technological initiatives, some similarities were found between global initiatives in the EU, UK and Asia as compared with those in South Africa; however, the focus of these differed slightly and the maturity of Smart Cities in developed regions as reported by Santana et al. (2018) was confirmed. The initiatives in the developed countries are well recognised as successful through international awards and/or rankings, and can be considered as best practice cases. Figure 1 illustrates the main themes identified for the purpose of Smart City initiatives based on Table 1 and Appendix A.

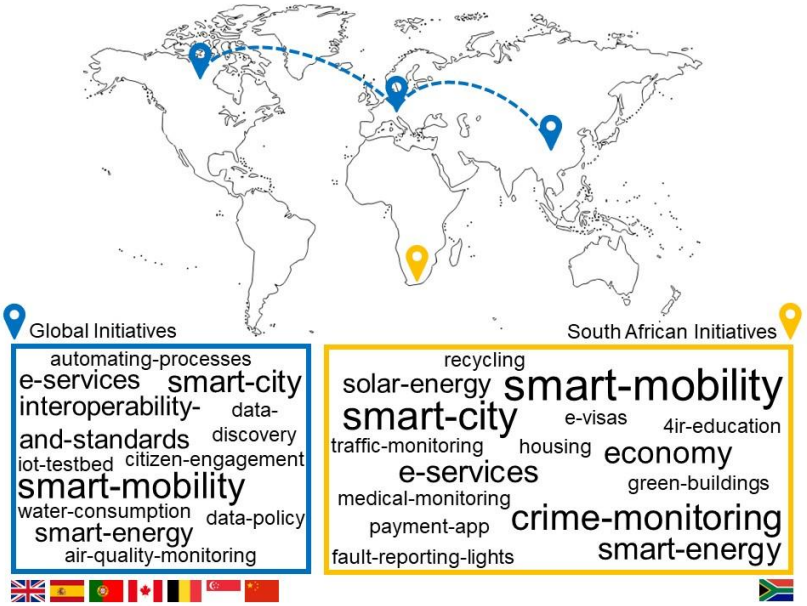

Figure 1. Purpose of Smart City Initiatives: Developed Economies vs South Africa

The main purpose of Smart Cities in the developed economies was to provide an integrated, connected Smart City providing efficient e-services, citizen engagement, mobility and energy to citizens. The initiatives addressed data integration and interoperability challenges through standards for public data sets such as W3C's DCAT, and standards for IoT such as JSON and HTTPS. Unfortunately, there is still little evidence of this maturity and success in South Africa where the majority of initiatives in South Africa addressed the economy, crime and some aspects of mobility. The Western Cape, Gauteng and KZN take the lead, but successful, mature initiatives are in the minority. The few Open Data portals for South African data are mostly out of date and at the time of writing this paper no maturity rankings are provided for such portals. The findings of this paper therefore confirm those of the 2017 SALGA report showing that African Smart City solutions are still implemented in isolation, where the focus is on city performance and not on dealing with pressing city needs (SALGA, 2017). These needs include access to education, water and energy (Musakwa & Mokoena, 2018) and should be addressed before attempting Smart Cities.

CONCLUSIONS AND RECOMMENDATIONS

In our digital society, transforming and transmitting digital information is critical, therefore a leading role has been given to new technologies, especially those dedicated to information flow in Smart Cities. The findings of this paper confirm those of Lea & Blackstock (2014), highlighting the critical need for Open Data platforms and for IoT to facilitate the success of Smart City initiatives and the realisation of digital citizens. Recommendations for practice are the best practice policies, standards, testbeds and funding initiatives identified, which can be used as a basis for planning initiatives in South Africa. The literature and websites reviewed confirmed the importance of making data available for citizens to use, particularly during a crisis such as the COVID-19 pandemic. Whilst Open Data initiatives are growing in South Africa, there does not seem to be any assessment of ODM as there is in Europe. There is a large gap in South Africa between what is required for Open Data and Smart Cities and what has actually been achieved. A rethink is required of what Smart City value is for South Africans; one that meets the real needs of citizens and has a positive impact on their access to technology and data to improve their social lives. South Africa and other emerging economies can benefit from assistance and funding from best practice Smart Cities. A limitation of the study was that some of the objectives were addressed using an exploratory review. Secondly, the case studies were mainly conducted on the European continent and in South Africa. Another limitation was that the web searches and related analyses were manually done by the authors and could therefore contain some bias. Future research should investigate other cases in emerging economies and automated analysis methods could be used. Future studies should also investigate improvements to policies, standards and the development of testbeds for Smart City and Open Data initiatives in South Africa.

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