

# Challenges that affect smart city implementation in small and rural municipalities

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**Background:** Small and rural municipalities have been struggling to address the issue of population and service delivery. In order to manage and address service delivery in rural areas. There is a need for new ways to improve the day-to-day operation of small and rural municipalities and the quality of life of their citizens, increase efficiency, manage resources and reduce municipality expenses.

**Objectives:** This study aims to investigate the challenges that affect the implementation of a smart city in South African small and rural municipalities.

**Methods:** A qualitative research methodology was employed to collect data through interviews from small and rural municipalities. The target population for this study was municipality personnel involved in decision making and those charged with smart city implementation responsibilities in South African small and rural municipalities.

**Results:** The results of this study revealed that insufficient Internet connectivity and a lack of digital infrastructure, technology, budget, sustainable energy and skilled workforce are the challenges that affect smart city projects in South African small and rural municipalities.

**Conclusion:** To execute and implement smart city projects successfully, South African small and rural municipalities should address the challenges before they start with their projects.

**Contribution:** The findings of this study will significantly contribute to the body of knowledge in the field of smart cities, information systems and rural studies by exposing challenges that may affect small and rural municipalities when engaging in a smart city project.

**Keywords:** small and rural municipalities; smart city; smart city implementation; smart city implementation challenges; South Africa; qualitative methodology.

## Introduction

Municipalities have evolved over time. Specifically, small and rural municipalities have changed in terms of population growth, characteristics and how they operate (Das 2020). One of the mandates of small and rural municipalities is to provide basic services to their population (Cilliers, Flowerday & McLean 2016). However, they are struggling to address population and service delivery issues because they face numerous challenges. Municipalities are struggling to manage their information effectively to allocate their resources to improve service delivery. This prevents small and rural municipalities from providing basic services to their citizens (Mashau, Kroeze & Howard 2021).

In addition, the population growth of small and rural municipalities negatively affects physical, institutional, social and economic infrastructure. The weakening infrastructure necessitates innovative approaches to enhance utility and service delivery, as well as the quality of life of the population (Chourabi et al. 2012; Maestre et al. 2018). Globally, cities are now putting more emphasis on the development of smart cities to improve the way they manage their resources, including small and rural municipalities or local governments (Cilliers et al. 2016; Das 2020). The majority of small and rural municipalities intend to develop smart cities to improve how they render services to their citizens (Bakici, Almirall & Wareham 2013).

From a South African perspective, various challenges prevent small and rural municipalities from developing smart cities. The problem is that there are limited studies that explore the

challenges that impede the implementation of smart city. Furthermore, the identified challenges are not empirically investigated in small and rural municipalities from a South African perspective. The aim of this study is to empirically examine the challenges that affect smart city implementation in South African small and rural municipalities.

This study is divided into six parts. The first part provides the introduction of the study and the second part presents a literature review focusing on unpacking the concept of a smart city. The third part provides an outline of the research methodology. The fourth part presents the findings and the fifth part presents the discussion, followed by a conclusion as the last part.

## Defining a smart city

The smart city concept is a novel and innovative method that enables a city to utilise its resources and infrastructure more effectively (Cilliers et al. 2016). Scholars have different definitions for this concept. Some scholars define a smart city as a city that is technologically connected (Mahesa, Yudoko & Anggoro 2019; Przybilowicz et al. 2018), while other definitions stipulate that a smart city is a city that uses digital infrastructure to manage resources in order to deliver services effectively (Arief et al. 2019; Chourabi et al. 2012; Clement, Manjon & Crutzen 2022).

A concise and uniform definition will aid scholars and practitioners in better understanding this concept, which is rapidly gaining popularity across the globe (Guo et al. 2018; Mahesa et al. 2019; Pedro & Bolívar 2018). In this study, a smart city is defined as:

[A] digital integration of information systems components to collect digital data and analyse it in real-time in order to monitor and manage the city infrastructure and to allocate resources effectively, thereby improving service delivery and the quality of life of the citizens. (Mashau et al. 2021:264)

## Smart city elements

Instead of focusing on a limited number of smart city services that are thought to make a municipality smart, the development of a smart city relies on the integration of physical, political, environmental, and socioeconomic aspects (Clement et al. 2022; Dewi et al. 2018; Kumar, Singh & Gupta 2019). Worldwide, municipalities are engaging in smart service projects to enhance service delivery and the economy, as well as to allocate resources (Hodzic, Alibegovic & Drazenovic 2021; Neupane et al. 2019). According to some scholars, municipalities can use smart services as a guide for implementing a smart city (Bustos & Sánchez-Ortiz 2018). Some research indicates that smart city services offer a novel and innovative method to connect communities with the municipality (Bustos & Sánchez-Ortiz 2018; Dewi et al. 2018; Sung et al. 2020).

As a result of a lack of resources, most small and rural communities struggle to provide services (Seetharaman,

Cranefield & Chakravarty 2019). A specific technique is needed to assist municipalities to manage their available resources successfully (Pereira et al. 2016; Vu & Hartley 2018). The idea is that realising and adopting the smart city concept can assist municipalities in improving how they manage their information and resources to improve citizens' standard of living, economy and service delivery (Clement et al. 2022; Fromhold-Eisebith & Eisebith 2019; Suresh et al. 2020).

Various elements are involved in realising the smart city concept. These elements include management support, appropriate infrastructure, citizens, appropriate technology, stakeholder participation, data, current policies and Internet connectivity (Mazurek & Stroinski 2019; Neupane, Wibowo, Grandhi & Hossain 2019).

Digital, social and economic infrastructure are the drivers of smart city development (Neupane et al. 2019; Sung et al. 2020). A smart city cannot function without modern technologies that are compatible with the digital infrastructure (Chourabi et al. 2012; Maestre et al. 2018). Therefore, technology and digital infrastructure are significant in encouraging an innovative spirit between different stakeholders and citizens (Sung et al. 2020). In most institutions, technology is the enabler towards achieving strategic objectives (Zhang et al. 2018). Even with modern technology and digital infrastructure in place, Internet connectivity is crucial for connecting a municipality with its residents (Bakici et al. 2013).

The literature highlights the fact that technology, citizens, Internet connectivity and digital infrastructure are important for generating digital data (Chourabi et al. 2012; Maestre et al. 2018). Citizens utilise smart devices that integrate different systems and technologies to generate data (Bakici et al. 2013). Furthermore, in a smart city, every transaction made by residents is a significant data source that can be analysed to produce information that will help decision makers (Clement et al. 2022; Dewi et al. 2018; Mazurek 2018).

Support from top management is essential for any effort to become a smart city. Literature postulates that top management must understand the aim of smart city projects and envision the benefits of implementing a smart city (Alawadhi et al. 2012; Clement et al. 2022; Dewi et al. 2018).

A municipality needs to procure the appropriate digital infrastructure, technologies and secure Internet connectivity and employees must have the support of management as decision makers (Dewi et al. 2018; Mahesa et al. 2019; Mazurek 2018). Furthermore, management decides which projects to prioritise in terms of funding (Alawadhi et al. 2012; Dewi et al. 2018). Only if there is buy-in from management will the smart city project be funded, otherwise it is likely to fail (Alawadhi et al. 2012; Dewi et al. 2018; Seetharaman et al. 2019).

Policies set the course of action for resolving each municipality's social issues, standard of living and service delivery challenges (Gunawan et al. 2018). As a result, when developing such policies, small and rural municipalities should consider important aspects of smart city implementation (Bustos & Sánchez-Ortiz 2018; Dewi et al. 2018; Sung et al. 2020). Unfortunately, policies may slow down the efforts to implement a smart city (Alawadhi et al. 2012; Dewi et al. 2018).

## Research methodology

### Research design

According to Crotty (1998), research methodology is a strategy that employs a certain technique to achieve desired results. The main approaches to research are quantitative and qualitative (Borgstede & Scholz 2021; Kothari 2004). This study followed a qualitative approach because it is frequently employed while attempting to comprehend complex phenomena. This is done by elaborating on, and explaining the phenomenon from the viewpoints of the participants (Leedy & Omrod 2001; Saunders, Lewis & Thornhill 2019).

### Population unit and sampling technique

The population unit of this study comprises five small and rural municipalities from two provinces in South Africa. These provinces were selected because they have many small and rural municipalities (Municipality Demarcation Board 2018). The researchers used purposive sampling to select the municipalities. The participants interviewed in this study are municipality personnel involved in decision making and those tasked with smart city implementation responsibilities.

Both purposive and snowball sampling methods were used to select these participants. Initial participants from each municipality were purposively selected. To identify more participants, snowball sampling was used. However, the literature is not conclusive about the population size for interviews. Some studies suggest that a sample unit for interviews should comprise a sample size of 5 to 25 participants (Marshall et al. 2013; Saunders 2012). Furthermore, other studies show that a study that employs interviews is likely to reach a saturation point at participant number 12 (Constantinou, Georgiou & Perdikogianni 2017). In this study, a saturation point was reached at participant number 14. Therefore, a total of 14 interviews were conducted to investigate the challenges that affect small and rural municipalities for smart city implementation.

### Data collection

Data were collected between March and September 2022 using semi-structured interviews. Each interview session took 30 to 45 min. Before each interview, permission to record was sought from the participants. With the permission of the participants, the interviews were then recorded using a digital audio voice recorder.

## Data analysis

In this study, thematic analysis was used to analyse data collected from small and rural municipalities' participants. To achieve this, the researchers started by transcribing all the recorded interviews using Microsoft Word. During the transcription, confidentiality was ensured by using pseudonyms (Participants 1 to 14) to identify the participants. Subsequently, the transcribed interviews were uploaded to ATLAS.ti to identify the codes that share the same meaning from the interview data. Open coding was used to code interview data. In open coding, data are chosen, categorised and compared in order to create themes depending on the expression and characteristics of the data (Holton 2010; Williams & Moser 2019). List coding was also used to create quotations using existing codes. The codes were subsequently grouped into themes.

## Ethical considerations

The study obtained ethical clearance from the University of South Africa (Unisa), College of Science, Engineering and Technology's (CSET) ethics review committee (ERC Reference #: 2022/CSET/SOC/001). The low risk application was expedited by the College of Science, Engineering and Technology's (CSET) Ethics Review Committee on 01 March 2022 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

## Findings

During data analysis, six themes were identified that represent the challenges affecting the implementation of a smart city in small and rural municipalities. The six themes are lack of infrastructure, Internet connectivity, technology, skilled workforce, budget issues and sustainable energy.

### A lack of infrastructure

Most of the participants indicated that small and rural municipalities have old and limited infrastructure. The existing infrastructure is not compatible with or suitable for developing a smart city in small and rural municipalities. In addition, even municipalities with the budget to procure infrastructure are struggling. The infrastructure is often not available locally and it becomes expensive to buy it from other countries. This poses a challenge for small and rural municipalities that are willing to upgrade their infrastructure. Interview participants identified infrastructure as something that is hindering small and rural municipalities from implementing a smart city:

'The challenges? It will be lack of infrastructure ...' (Participant 1)

'Availability of infrastructure sometimes is a problem because sometimes we end up getting them from overseas and sometime, we pay a lot. Hardware failure, this happened a lot.' (Participant 3)

'Ah, our infrastructure is old, there is no way that we can implement smart city using it.' (Participant 8)

'Mmm, we have old infrastructure and software. I don't think with what we have you can develop or implement smart city.' (Participant 10)

'Lack of suitable infrastructure, is one of the challenges ...' (Participant 12)

## Internet connectivity

Internet connection is a pivotal component in a smart city because it is used to connect the citizens with the municipality. Participants indicated that in a smart city, citizens should have access to the Internet at all times regardless of their location. However, the results show that certain areas have no Internet access at all. To implement a smart city successfully there is a need for affordable Internet access. Therefore, Internet connectivity is flagged as an area that needs special attention when a municipality plans to implement a smart city:

'We are a rural town or municipality dominated by rural areas and farms and as a result, we have internet connectivity issues in most areas. At the moment in the area where there is coverage, we are experiencing network challenges because of loadshedding. Once there is loadshedding, you know that you won't have access to the internet. And we don't see or we have never heard what these network providers have in place in order that even if there is no electricity but we continue receiving networks to communicate. Once the electricity is gone you can't hotspot with your cell phone and everything cuts off. So those are the challenges that I think they make things impossible.' (Participant 1)

'Yes, there is a need of accessible and affordable internet connectivity to connect the municipality with the people out there, with the community.' (Participant 10)

'Oh, before I forget, the issue of internet connectivity, if you go to deep rural villages like Mukondeni there is no coverage on most internet service providers. There are lots of challenges that need to be addressed before you can start with the development of a smart city.' (Participant 13)

## Technology

The findings show that technology affects smart city development in several ways. Interview participants indicated that it is a challenge for municipalities with a tight budget to secure licences for the latest technologies. The findings indicate that most of the latest technologies are not compatible with existing outdated infrastructure:

'Technology, we don't have a budget to buy licences for modern technology. So, infrastructure-wise and technology-wise we are not yet there.' (Participant 8)

'I think we are still lacking behind in terms of technology ...' (Participant 9)

'IT infrastructure I think it won't be compatible with latest technology. This too will need some improvement.' (Participant 14)

## Skilled workforce

The participants of this study indicated that a skilled workforce who has the knowledge to utilise various digital

technologies is critical in the implementation of a smart city. Without a skilled workforce it would be challenging to implement a smart city successfully. Furthermore, the findings also show that only a small number of citizens have the knowledge and skills to operate the latest or modern innovations. Therefore, municipalities should improve their capacity by upskilling their workforce with the relevant skills to execute smart city projects:

'The very same institutions, including the citizens, should have and know how to use various technology and smart devices.' (Participant 6)

'Oh, yeah, probably, thanks, I think obviously skill and other factors will be part of the challenges. Obviously, capacity is a challenge because at the moment we are talking about 4IR and we don't have a budget for that. We don't have the skill for that, let alone a smart city.' (Participant 9)

'Lack of capacity in terms of skills from a human resource perspective.' (Participant 12)

'Even the skill to implement different technologies, we don't have.' (Participant 13)

## Budget issues

Municipalities should have sufficient budget to fund their projects. The participants indicated that small and rural municipalities do not generate enough profit. Furthermore, they indicated that municipalities depend on government grants and subsidies to fund their projects. Budget is critical when developing a smart city. Municipalities should budget for the required digital infrastructure, technology and reliable Internet connection, to name a few:

'Yes, they are very relevant because I mean you can't develop without budget.' (Participant 7)

'A lack of budget will affect the implementation of a smart city. Looking at our municipality we rely on grants and donations. We don't make enough revenue that I can say we will use to fund smart city initiatives.' (Participant 11)

'First thing is the budget, budget is very important, especially for our municipality, I would say we are still lacking in terms of servicing our citizens adequately. So, how can we implement a smart city whereas we are still lacking in such areas? Budget is very crucial in this case.' (Participant 14)

## Sustainable energy

The interview data show that the issue of sustainable energy or electricity is a challenge in South Africa. In addition, the findings show there is a need for sustainable energy in a smart city. Interview data show that persistent loadshedding presents serious challenges to the South African small and rural municipalities that intend to develop a smart city:

'Another issue will be electricity. We need sustainable energy because the fancy technology is dependent on electricity. With the rate of loadshedding it will be difficult to implement sustainable energy.' (Participant 11)

'The issue of stable electricity.' (Participant 12)

## Discussion

The evaluation of smart city challenges reveals that small and rural municipalities have various challenges. Specifically, these municipalities have challenges around infrastructure, technology, skilled workforce, budget, sustainable energy and Internet connectivity. The analysis of the investigation of various scholars shows that in order for municipalities to implement a smart city, they require modern digital infrastructure and technology (Bakici et al. 2013; Morozov & Bria 2018). Previous studies postulate that for a municipality to implement a smart city successfully, it must be prepared technologically and infrastructure-wise (Alawadhi et al. 2012). However, the literature shows that sometimes it might be difficult to implement various technologies in rural areas because of their geographic location and low population density.

In addition, the interview data indicate that most parts of the small and rural municipalities do not have access to the Internet. The literature suggests that the Internet should connect the citizens and municipalities in a smart city (Bakici et al. 2013; Morozov & Bria 2018). The literature presents digital infrastructure and technology as the main driver, with Internet connectivity enabling the digital infrastructure to communicate with the technology to generate digital data (Alawadhi et al. 2012; Bakici et al. 2013; Morozov & Bria 2018). Therefore, to enable the successful implementation of a smart city, municipalities should ensure that there is a reliable Internet connection. However, the literature postulates that it is challenging to construct Internet connectivity for everyone in these areas because of the dispersion of dwellings.

Different scholars concur with the findings of this study that for a municipality to engage in a smart city project, it should have the budget to fund procurement and day-to-day operation, as well as the upgrade of its digital infrastructure, if needed (Alawadhi et al. 2012; Dewi et al. 2018). Therefore, the municipalities should also conduct a readiness assessment to ensure the success of smart city development (Dewi et al. 2018). The analysis of various literature indicates that a municipality requires a skilled workforce. However, the interview data show that South African small and rural municipalities lack a skilled workforce (Berst et al. 2014; Yigitcanlar et al. 2021). In addition, the municipality should be able to raise funds to capacitate the skilled workforce.

There is no one-size-fits-all solution to address all the identified challenges in this study. Therefore, small and rural municipalities should devise an approach suitable to their unique setting and demands to address all the challenges that may stop them from implementing a smart city.

## Conclusion

The aim of this study was to investigate the challenges that small and rural municipalities encounter when

implementing a smart city. To achieve this aim, data collected from small and rural municipalities' officials were uploaded on ATLAS.ti and analysed using thematic analysis. Thereafter, six challenges that affect smart city implementation were explored, namely a lack of infrastructure, Internet connectivity, technology, budget issues, sustainable energy and skills. To implement a smart city successfully, it is necessary for small and rural municipalities to address these challenges before they start with the project.

A few limitations were identified. Because the study used a purely qualitative approach, there is room to complement the research with quantitative methods to statistically test the results. Thus, future studies are encouraged to examine the awareness of the challenges that may impede the implementation of a smart city in the small and rural municipalities.

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The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

## Authors' contributions

Mr N.L.M. produced this article from PhD work supervised by Prof. J.H.K. They worked hand in hand to produce this article.

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## Data availability

The data that support the findings of this study are available on request from the corresponding author, N.L.M.

## Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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