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A Readiness Assessment Tool for Smart City Implementation in Small and Rural Municipalities

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Abstract

Small and rural municipalities are lagging in terms of implementing a smart city. These municipalities have limited resources to provide basic services to the citizens. There is a need for these municipalities to implement a smart city to manage resources effectively. However, an assessment tool to assess small and rural municipalities' readiness for smart city implementation is lacking. This article offers such an assessment tool tailored specifically to assess small and rural municipalities' readiness for smart city implementation. Design science research methodology (DSR) was used in a wider study to develop a related smart city readiness framework. In the preceding cycles of the DSR study, a literature review was used to provide relevant data for the construction of a conceptual framework, which was validated and improved using semi-structured interviews in a second and third cycle. The last cycle of the research developed and validated an assessment tool as an artefact that could be used to address critical issues, including limited resources and governance complexities that are unique to these municipalities. The findings showed that the proposed tool covered all the salient aspects, except for the aspect of smart buildings that are capable of collecting data without human intervention. This element was added to the final assessment tool. The tool can be used by personnel and consultants who are responsible for developing or implementing a smart city in small and rural municipalities. Furthermore, what makes this assessment tool unique is its alignment with the needs of small and rural municipalities. It was validated through participatory and expert reviews, providing a reliable instrument for policymakers and municipality managers in making an informed decision toward the readiness assessment of a smart city. A formula to calculate a municipality's readiness level quantitively as a percentage, as well as a proposed evaluation heuristic, is also provided. The final, revised assessment tool prompts actionable insights informing the implementation of a smart city in small and rural municipalities.

Keywords: Smart City, Municipalities, Smart City Assessment Tool, Smart City Implementation

1. INTRODUCTION

Limited resources in small and rural municipalities make planning and allocating resources for service delivery difficult [1], [2]. Furthermore, population growth mounts more pressure on existing resources leading to more problems [3], [4].

Other resources end up breaking down. Due to this, small and rural municipalities struggle to manage high crime rates, garbage accumulation, water provision, sanitation, houses, access to energy, and air quality, to name a few [5], [6]. These challenges can be minimized by implementing the concept of a smart city in small and rural municipalities [7]–[9]. Globally, municipalities are embracing the smart city concept [10]. This concept has been researched for decades by many scholars looking at big, small and rural municipalities [11].

Small and rural municipalities are struggling to implement a smart city despite extensive research in the smart city field [8]. However, Arief et al. [10] highlighted that the existing conditions of small and rural municipalities are not assessed or measured before implementing a smart city, resulting in a high failure rate of smart city projects. Although there are many published studies in the smart city field, small and rural municipalities don't know where to start when they want to implement a smart city [7], [10], [11]. However, the current literature lacks a study that explored and developed an assessment tool to assess or measure the readiness of the existing conditions for small and rural municipalities for smart city implementation. Furthermore, small and rural municipalities still have significant challenges like inadequate infrastructure, lack of relevant technical expertise and governance issues. Existing readiness assessment tools fail to address these unique requirements that result in the failure of many smart city projects. Therefore, this study aims at developing an assessment tool to assess small and rural municipalities' readiness for smart city implementation to address the need of an instrument to gauge the readiness level for smart city implementation in small and rural municipalities.

The article is arranged as follows: Section 1 presents the introduction to the study. Section 2 defines smart city concepts and provides an overview of important aspects of smart city implementation. Section 3 discusses the research methodology applied to achieve the aim of the study. Section 4 presents the findings and discussion of the study, and Section 5 presents the discussion, and the last section concludes the study.

2. LITERATURE REVIEW

2.1. Smart City

IBM coined the smart city concept to integrate different city subsystems by adopting advanced technologies to ensure that a city is run intelligently [12]. A smart city uses technology to integrate cutting-edge information and communication technologies like cloud computing and the Internet of Things (IOT) to promote urban governance [13], [14]. Urban governance aims to ensure the provision of public services and improve people's lives [5], [13].

The term "smart city" has been defined in many ways, with the majority of researchers placing a strong emphasis on the application of technology to manage resources and provide basic services to the citizens [15]–[18]. In this study, the smart city concept is defined as "a digital integration of information systems components to collect digital data and analyze it in real-time to monitor and manage city infrastructure and to allocate resources effectively, thereby improving service delivery and the quality of life of the citizens" [8].

2.2. Smart City Key Indicators to Access Municipalities' Readiness

Assessing municipalities' readiness for smart city implementation requires the identification of key indicators that can help measure the readiness level. The literature suggests technology, environment, and organization as key indicators [19], [20]. However, Desdemoustier et al. [7] indicate that there is also a need to measure the human perspective when assessing municipalities' readiness.

2.2.1. Technological indicator

When measuring municipality readiness, there is a need to look at various technologies that will enable a smart city [21]–[23]. The literature postulates internet connectivity, sensors, open data and security as critical technologies that must be assessed to ensure that the municipality is technologically ready [24]–[26]. A smart city requires high-speed internet and wireless connectivity [26]. These components are essential because they enable data-driven decision-making and ensure a smart city's smooth functioning [27], [28].

Sensor networks are a key component of smart city operations [29], [30]. Municipalities that have deployed sensor networks to collect data on various areas such as water provision, energy management, air quality, traffic, and waste management, are better equipped to monitor and manage their city's resources and services efficiently [29], [31]. The municipalities should also ensure open data policies and platforms exist to improve transparency and enable citizen engagement in smart city initiatives [32], [33].

Municipalities with open data policies and platforms are more likely to have successful citizen engagement, innovation and collaboration outcomes [34], [35]. There is a need for security measures to ensure citizens' personal information is protected. Security is critical for the success of smart city initiatives [36], [37]. Municipalities with robust security systems and protocols are better equipped to protect their smart city systems from cyber threats and to ensure the privacy and security of citizens' data [38], [39].

2.2.2. Organizational indicator

Assessing a municipality to become a smart city can be a complex task that requires the analysis of a range of factors [40], [41]. Organizational indicators can be used to assess the municipalities' readiness for smart city implementation [8]. One possible way to approach this task is to use a set of components to assess organizational readiness. In municipalities, a few components could be used to assess readiness for each area [8], [9], [40]. As an organization, the municipality should ensure that there are innovative people, citizens, and the skills required to develop a smart city [42], [43]. Furthermore, they should ensure the infrastructure can support the development of a smart city [40]. The municipalities should be in a state where they can engage with different stakeholders. These components can help to identify municipalities' strong and weak areas. This will help the municipalities to develop strategies to address their shortcomings [40]–[42].

2.2.3. Environmental indicator

The environment is critical when implementing a smart city in municipalities [11], [40]. When examining the environment, sustainable energy, buildings, and policies are pivotal. Cities should adopt energy-efficient technologies to manage and evaluate energy consumption patterns [40], [44]. Furthermore, the buildings in the municipalities' environment should be tools that assist a city in real-time data collection [45], [46]. However, there must be policies that govern data collection in the municipalities. In addition, these policies must support smart city development [32], [47], [48].

2.2.4. Human indicator

Assessing the readiness of small and rural municipalities for a smart city implementation can be challenging as their needs and resources may differ significantly from those of larger urban areas [25], [49]. However, it is crucial to assess citizens' engagement or support of smart city projects [50]. The literature shows that municipalities with an active and engaged citizenry are more likely to successfully implement a smart city [25], [50]. In addition, the literature indicates that assessing readiness for a smart city implementation requires a holistic approach that considers a range of factors [40], [42]. By evaluating citizens' engagement, experience, skill, qualification, and leadership, one can comprehensively understand human readiness toward smart city implementation [51], [52].

3. RESEARCH METHODOLOGY

Design science research methodology (DSR) was used in a wider study to develop a related smart city readiness framework. In the preceding cycles of the DSR study, a literature review was used to provide relevant data for the construction of a conceptual framework, which was validated and improved using semi-structured interviews in a second and third cycle. The last cycle of the research developed and validated an assessment tool as an artefact that could be used to address critical issues, including limited resources and governance complexities that are unique to these municipalities.

DSR is an approach that is used to develop scientific knowledge [53], [54]. A final scientific contribution to a DSR project is an artefact to solve business problems [53]. Researchers may follow various DSR approaches when designing an artefact. The three approaches used commonly were formulated by Peffers et al. [55], Kuechler and Vaishnavi [56] and Drechsler and Hevner [57].

Design science research methodology is suitable for a study that seeks to develop an artefact through several iterations. This study followed the DSR approach by Peffers et al. [55] because it is explicit regarding the iterations that must be instituted [55]. This model demonstrates a structured approach that may be followed when carrying out an investigation in the information systems domain and related fields. The researcher must start by identifying and motivating a problem. After identifying the problem, the researcher must define the objectives for the potential solution in order to address the problem. Subsequent to this stage, the artefact should be developed that will serve as a practical solution to the problem. The artefact is then demonstrated in a specific context to evaluate its suitability. Lastly, the findings of the investigation should be communicated in the form of scholarly or professional publication.

The iterations followed in this study to develop the integrated assessment tool, are aligned with those of the DSR process proposed by Peffers et al. [55], as follows:

1) **Iteration 1**: The researchers identified the problem and provided motivation for addressing it (see Section 1).
2) **Iteration 2**: The researchers defined the objectives for creating an integrated assessment tool to assess small and rural municipalities' readiness for smart city implementation (see Sections 1 and 2).
3) **Iteration 3**: Thereafter, the researchers designed and developed the integrated assessment tool using interview findings (see Section 4.2).
4) **Iteration 4**: The integrated assessment tool is tested for its suitability through participatory design (see Section 4.3).
5) **Iteration 5**: The integrated assessment is further tested and evaluated through expert review (see Section 4.4).

6) **Iteration 6:** The results of the research are communicated in this study.

3.1. Sampling

In the wider study, referred to above, a multistage sampling technique was employed to ensure diverse and representative data collection. In the initial stage, purposive sampling was employed to select three South African provinces with a good mix of small and rural municipalities. Furthermore, small and rural municipalities were selected using purposive sampling. Lastly, to select initial participants, purposive sampling was used. In the subsequent stage, snowball sampling was used. The artefact was evaluated using a participatory design by identifying participants from the interviewees through snowball sampling. The research requested a gatekeeper to nominate one person from the interview pool from each municipality. The artefact in a form of assessment tool was validated using expert review. The experts comprised managers from metropolitan municipalities in South Africa and researchers knowledgeable in the smart city field. This iterative approach ensured the inclusion of participants who provided valuable insights into the development and validation of the assessment tool.

3.2. Data Collection and Analysis

Qualitative data was collected from five local municipalities from three different provinces in South Africa. Data from municipalities were collected from 14 participants through individual face-to-face semi-structured interviews. The data was later analyzed through thematic analysis using ATLAS.ti 8.1. The research process involved transcribing all interviews and saving them in Portable Document Format (PDF_ documents, which were then uploaded into ATLAS.ti). The transcripts on ATLAS.ti were thoroughly reviewed while identifying codes, which were subsequently grouped into themes. An assessment tool was developed and evaluated by the municipality representatives from the interview pool through an online survey. The assessment tool was further validated by a group of experts through an online survey. All the collected data were analyzed to develop a finalized assessment tool.

4. RESULTS AND DISCUSSION

4.1. Interview Findings

Before analyzing the data, all recorded interviews were transcribed using Microsoft Word and uploading the transcripts into ATLAS.ti. Furthermore, the researcher used ATLAS.ti to identify and create codes. Later on, codes were grouped into three themes: factors that are critical in assessing small and rural municipalities'

readiness for smart city implementation, important drivers for smart city development, and perceptions regarding measuring small and rural municipalities' readiness levels for smart city implementation. The analyzed data were used to design and develop an initial assessment tool depicted in Table 1.

4.1.1. Factors that are critical in the assessment of small and rural municipalities' readiness for smart city implementation

Interview findings show a need to assess technology and human readiness. Interview participants indicated that the citizens must first understand the values of digital devices in a smart city. In the literature, citizens are seen as significant contributors to a smart city [58], [59]; they should know how to operate digital devices and their technologies. If they do not see the value of digital devices in a smart city, they won't bother to learn how to use them.

Interview participants further indicated that a lack of technical skills from citizens could affect the implementation of a smart city in small and rural municipalities. Furthermore, to ascertain human readiness, small and rural municipalities must ensure that both citizens and staff have the required technical skills. This will also improve human capacity in small and rural municipalities.

"Another thing, if they are not ICT wise about using all the gadgets and other technological ICT related mechanisms that can be brought in because of that smart city concept, it cannot be maximally utilized because people won't understand the value of those particular gadgets or technologies. Yes, those will be hindrances or challenges in a journey of developing a smart city." (Participant 1)

"You even went with the fourth one, which is your human readiness because it assesses the technical skills of both municipality staff and citizens." (Participant 5)

"I think first you must assess human resource capacity. Determine if you have relevant or required capability or skills." (Participant 11)

The interview participants also believe that small and rural municipalities should have an appropriate infrastructure for smart city development. They further indicated that the required infrastructure should include social, physical, and economic infrastructure because they are critical in developing a smart city in small and rural municipalities. A municipality should have a digital infrastructure in place that is compatible with different technologies to collect digital data. Furthermore, this infrastructure should be able to connect to the internet because, in a smart city, the municipalities should be able to collect data through sensors.

"To me, social infrastructure, physical infrastructure, and economic infrastructure are important factors in the implementation of a smart city. We cannot have a smart city without having these factors in place because these are the pillars of a smart city." (Participant 4)

"Remember I said a municipality should have suitable infrastructure and technology that can help the municipality to collect and analyze data. For you to collect the data, we are talking about you need a network or internet connection." (Participant 10)

"So, rural municipalities should have connectivity. You also want to connect the person who is in a village, must also have access to an internet connection and all of that. So, hence I am saying it's important because it connects people; whether rich or poor, they need to be connected." (Participant 2)

"You need sensors because you can't run a smart city without IoT (Internet of Things). So, sensors are crucial." (Participant 13)

Furthermore, one should examine the municipality as an organization when assessing readiness. This means the assessor should conduct an organizational readiness assessment. A municipality should at least generate 50% revenue to develop a smart city. Interview participants believe that municipalities that are dependent on grants and sponsorships are likely to fail to implement a smart city. Another thing that will affect a smart city implementation from an organizational point of view is the change of political appointees in the municipality. This brings instability in the municipality because a new leadership comes with a different vision.

The political element plays a pivotal role in the municipalities regarding project prioritization. Participants' findings show that a project should get support from political leaders to be prioritized. Otherwise, the project is likely to fail. This postulates that if a project has political support, it will likely be allocated enough resources and budget. The findings show that money is not a significant aspect of smart city development. The interviewees also indicated that a municipality should have skilled staff and appropriate technologies.

"As a municipality, you should maximize the available revenue sources not relying on grants and equitable share. Once the revenue collected by that municipality is above 50% of this budget, then you can start to initiate projects like a smart city project. A budget, and revenue collection is key for a small municipality like us." (Participant 1)

"The political element is also a key factor, you see these changes of politics, the politics, actually I can say is one of the factors that sometimes municipalities are not stable or sustainable because you have this mayor. Today you discuss or present his vision and all organizational structure support it; tomorrow, while you are starting to get your grip, comes another mayor. This creates

lots of holes because a new mayor will come with his vision. Instead of continuing with the predecessor's vision, they will tell you that this is not important and focus on something else like giving the community grocery parcels. So, politics is the key and if you don't have buy-in from politicians, chances are the project won't see the light of day." (Participant 3)

"Availability of willing human resources and the budget to implement a smart city. If the officials running the municipality and the decision makers are slow to adopt new technologies or not open to new ideas that could hamper and affect service delivery, or there is no budget or plans within the budget to fund such initiatives, the chance of failing to implement a smart city is high." (Participant 6)

"If you talk about organizational readiness, it can even go as far as saying, you have skilled staff, technology, and the money to fund the project, you know." (Participant 9)

In addition, participants' findings show that the environment is critical. Most small and rural municipalities are based in former homelands areas. The participants further indicated that the land in the homelands belongs to the traditional leaders. Therefore, the findings show that small and rural municipalities should regard traditional leaders as stakeholders.

"As a municipality, we are very small, and we are situated in the homelands, and we don't have that capacity." (Participant 1)

"Traditional leaders are some of the stakeholders. For example, in our municipality, most of the land belongs to the traditional leaders. So, in everything we want to do, we have to engage them." (Participant 4)

"In our municipality, most of the land is owned by traditional leaders. Yes, I would say traditional leaders are critical." (Participant 12).

Loadshedding is seen as a serious challenge to the development of a smart city in the homelands. Loadshedding affects the internet, and citizens cannot use their devices to contribute to a smart city. In addition, digital devices like sensors cannot communicate with each other when the internet is down. The interview participants indicated that a smart city needs a smart way to generate sustainable energy. Available energy should also be affordable to the citizens and the municipality should have a stronger economy.

"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)

"When looking at the loadshedding and load reduction that we are experiencing lately, we really need smart energy that will enable technology, sensors, and infrastructure to operate 24 hours

without failure. If there is no electricity, some areas don't have network connectivity and citizens cannot access some of the applications. That is why I say we need smart infrastructure, smart technology, and smart energy to implement a smart city. But at the moment we don't have any of these services." (Participant 3)

"Parastatals like Eskom and Nersa should ensure that you have affordable and sustainable electricity. With the current load shedding, a smart city can be just a talk and talk." (Participant 8)

"You need a city where the economy doesn't die. You know, because once the economy dies, you know, the creation of jobs dies as well. There won't be people that are employed in that particular town. You know, but if the economy thrives, you know, it's sort of, you know, generate income to the municipality because people will be paying rates and taxes." (Participant 5)

4.1.2. Important drivers for smart city development

Interview data show an agreement among interview participants. They have indicated that technologies, data, software, infrastructure, people, internet connectivity and processes are important information system drivers for smart city development. The participants have identified internet connectivity as critical because it enables the municipalities to collect important digital data that will help them manage and utilize their resources effectively.

Furthermore, interview data showed people are the end users of the smart solutions notifying the municipality about basic service issues. These smart solutions bring the municipality to the people in real-time. As indicated earlier, internet connectivity is critical. All the smart solutions should be connected to the internet to connect citizens with the municipality.

"I think, yeah, the most important is network connectivity. Without network connectivity, you do not have an environment in which you can develop a smart city. There is no use in having all these smart gadgets and stuff when you won't be able to use them because of connectivity issues. I think it is one of the drivers in a smart city." (Participant 1)

"We need to make sure; people are important because they are the ones that will be using smart solutions, and they will benefit from living in a smart city concept because most of the things they need will be at their fingertips. But hardware is where we store information, where we get information, and is where we actually get to take out that information and give it to those people who use it to make the decision. So, if hardware and software are broken, so we cannot work or assist people and to us it is like a dead day. We need to make sure that what things that are needed to help us to implement the smart city is 100% excellent." (Participant 3)

"I think we need modern hardware, software and data or information. Or yeah, even internet connectivity is important because the software must communicate through some sort of network." (Participants 10)

The participants indicated that their municipalities have some key information system drivers, even though some are outdated. Interview data show municipalities have hardware infrastructure they use to capture, store, and approve citizens' applications. They also use existing infrastructure to store data and communicate with staff and citizens.

"I think we have the technology, infrastructure, data, even GIS systems. But most of these information system drivers are not 100%. For example, our computers and printers are very old." (Participant 4)

"Yes, as an institution we have infrastructure and technology, but they are old." (Participant 6)

"Ah, our infrastructure is old. There is no way that we can implement a smart city using it. Technology, we don't have a budget to buy licenses for modern technology. So, infrastructure-wise and technology-wise we are not yet there." (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)

"We only have basic infrastructure as a municipality: your hardware, software, and internet connection. We use our computers to capture and approve applicant applications; to send and receive emails, write reports and nothing much." (Participant 13)

4.1.3. Perception of measuring small and rural municipalities' readiness level for smart city implementation

All the participants agree that assessment before a smart city project is important. In addition, interviewees have indicated that assessing or measuring small and rural municipalities' readiness levels before implementing a smart city is critical because it will help to identify the areas that need improvement. They further indicated that assessing the readiness level will help the municipalities to reduce the cost and time of implementing a smart city.

"Yes, obviously you cannot start without examining your ground if it is fit, you need to first plan and assess if you have all required resources." (Participant 1)

"So, conduction of the assessment helps you to see where you are lacking, to see where you are as a municipality you are in terms of technology and infrastructure." (Participant 3)

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"Assessing readiness–it will be an ideal move to examine your preparedness, and this will help us as a municipality to lay the foundation for smart city implementation. I think yes. Since we are in the planning phase of the smart city initiative, we will examine our state in order to figure out what we must improve." (Participant 8)

"This is like when you want to build a house, first you have to assess the soil if is suitable for the house that you want to build in order to avoid future problems. Without a thorough assessment, you might spend a lot of money in the long run because of cracks and other issues. I think this is important because it minimizes the cost and time." (Participant 13)

4.2. Development of an Assessment Tool

During the interview, participants were asked how small and rural municipalities' readiness for smart city implementation could be determined. They suggested that the assessor needs an assessment tool measuring the municipalities' readiness level by assessing the work they have done in certain areas.

"Yes, maybe you can have statements where whoever is assessing readiness they can tick. That is my suggestion." (Participant 4)

"Okay, all the factors that I identified earlier can be used as indicators in the form of a checklist to guide using yes or no as assessment criteria. In this instance, you check if you have skilled staff, if you have, you tick yes; if you don't have, you tick no, that will show that you don't have." (Participant 5)

"Yes, this framework is good, but I think you should have all these aspects in a table format where you will have tick boxes that the assessors will use to highlight the things they have as a municipality. For that, you can use Yes or No options. Therefore, if the statement says, Do you have modern technologies? If they have them, the assessor will tick Yes." (Participant 9)

Therefore, after analyzing interview data, the researchers developed an assessment tool to assess small and rural municipalities' readiness for smart city implementation. The assessment tool depicted below comprises four main indicators: human readiness, technological readiness, organizational readiness, and environmental readiness. All these indicators can be measured to assess a municipality's readiness level.

For each statement, select "Yes" if you agree or "No" if you disagree in the third column. Enter the number that best represents your municipality's readiness in the fourth column. The scores are interpreted as follows: 0 = 0% ready, 1 = 10% ready, 2 = 20% ready, 3 = 30% ready, 4 = 40% ready, 5 = 50% ready, 6 = 60% ready, 7 = 70% ready, 8 = 80% ready, 9 = 90% ready, 10 = 100% ready.

Table 1. An Assessment Tool to Assess Small and Rural Municipalities' Readiness for Smart City Implementation

No.	Human readiness	Yes/No	Score (0-10)	Comment
1	There are citizens in this municipality with the relevant educational qualifications for smart city implementation.			
2	There are citizens in this municipality with the relevant experience to develop a smart city.			
3	There are innovative citizens in this municipality who can contribute to the development of smart city implementation.			
4	The citizens in this municipality possess the required skills to implement a smart city.			
5	The citizens in this municipality are in support of smart city development.			
6	There are enough people with the relevant technical skills in this municipality to contribute to the implementation of a smart city.			
	Human readiness total score			
	Technological readiness		**Score (0-10)**	**Comment**
7	There are relevant social, physical, and economic infrastructures within this municipality.			
8	Modern technologies required for smart city implementation are available within this municipality.			
9	The modern infrastructure required for smart city implementation is available within this municipality.			
10	The available modern technologies are compatible with the municipality's existing infrastructure for smart city implementation.			
11	Vendors of modern technologies and infrastructure are available and accessible within this municipality.			
12	Modern technologies and infrastructure are affordable.			

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13	The available technology and infrastructure are suitable for collecting and analyzing data in real-time.		
14	The analyzed data will provide the municipality with the information for decision-making in real-time.		
15	The infrastructure supports internet connectivity.		
16	The available technology and infrastructure are secured.		
	Technological readiness total score		
	Organizational readiness	**Score (0-10)**	**Comment**
17	The municipality management supports you as a municipality in implementing a smart city.		
18	You have support from politicians for a smart city project.		
19	The municipality has partnerships with the public and private sectors.		
20	There are employees with the relevant educational qualifications for smart city implementation.		
21	There are employees with the relevant experience to develop a smart city.		
22	There are employees with the relevant technical skills to implement a smart city.		
23	The municipality has the required resources to implement a smart city.		
24	This municipality generates 50% of its revenue.		
25	There is a budget to fund smart city initiatives.		
	Organizational readiness total score		
	Environmental readiness	**Score (0-10)**	**Comment**
26	There is a reliable internet connection within the municipality.		
27	You have reliable and sustainable energy.		

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28	Policies support smart city development in the municipality.
29	The municipality personnel and citizens comply with the policies to promote good governance.
30	You have buy-in from traditional leaders.
31	You have a strong economy to ensure smart city development.
	Environmental readiness total score
	The overall score for the municipality's readiness: (To calculate the overall score, calculate the overall total of all the scores or total scores above.)

4.3. Findings of the Evaluation of the Assessment Tool through Participatory Design

The assessment tool in Table 1 was sent to the representatives from the pool of interviewees selected from each municipality. The evaluation iteration was conducted to confirm that participants' input is reflected correctly in the developed assessment tool. The data for this iteration was collected through an online survey using Google Forms. The link was disseminated to all selected participants using an email.

The participants agreed about the assessment tool's relevancy in assessing small and rural municipalities' readiness for smart city implementation. They further indicated that this assessment tool is unique because it was specifically designed for small and rural municipalities, zooming into their daily challenges. They also highlighted that this assessment tool has come during the right time when most of the small and rural municipalities are contemplating implementing a smart city.

During the evaluation process, the participants were asked to examine the assessment tool and identify any missing aspects. The participants' findings showed that the selected participants were satisfied with the assessment tool because their input was reflected correctly. Based on this, no changes were made to the developed assessment tool to assess small and rural municipalities' readiness for smart city implementation.

4.4. Findings of the Validation of the Assessment Tool through Expert Review

The assessment tool was also validated by a group of experts in a smart city field and metropolitan municipality managers who have worked on a smart city

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initiative. This iteration was conducted to confirm the suitability and identify the usability of the assessment tool. The data for this iteration was collected through an online survey using Google Forms. The link was sent to all selected participants using an email. Only seven participants provided their feedback about the assessment tool.

The findings indicated that the assessment tool is relevant to assess small and rural municipalities' readiness because it was developed focusing on small and rural municipalities, and it takes into account that small and rural municipalities' characteristics and roles are different from those of district and metropolitan municipalities.

"Highly relevant." (Participant 1)

"One advantage of the revised framework is that it is tailored specifically to small and rural municipalities, which may have unique challenges and opportunities when it comes to implementing smart city initiatives. The framework takes into account the specific needs and characteristics of these municipalities, which may differ from larger, more urban areas. The framework is relevant." (Participant 5)

"Very relevant and easy to follow." (Participant 7)

The participants were further asked to examine and comment on any missing aspects of the assessment tool. Most participants agreed that the assessment tool is comprehensive, while some indicated that it covers everything that is critical to assess small and rural municipalities' readiness for smart city implementation. However, a few respondents showed that there is a need to add a building component under the environmental readiness indicator.

"I am not able to judge but I think the framework is comprehensive." (Participant 1)

"Overall, the revised integrated framework and assessment tool are comprehensive tools to assess small and rural municipalities. The framework covers every area." (Participant 5)

"I think there is a need to assess buildings/homes under an environment." (Participant 6)

"None." (Participant 7)

Based on the participants' feedback, the assessment tool was revised by adding a building component (see Table 2). A formula to calculate the municipality readiness level quantitively as a percentage, as well as a proposed evaluation heuristic, is also provided.

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4.5. Finalized Artefact

This subsection presents the finalized assessment tool as an artefact of the study. It is divided into four main indicators: human, technological, organizational, and environmental readiness. The assessment tool has five columns, of which columns three and four are mandatory when assessing smart city readiness. Assessors may complete column five if they want to comment.

The assessor must complete column three by filling in "Yes" if something is done in that area and "No" if nothing is done in that area. In the fourth column, the assessor must fill in a score between 0 and 10. If the selected option in the third column is "No", the score must be zero "0". But if the selected option is "Yes", the score should be between 1 and 10. These scores are interpreted as follows: 0 = 0% ready, 1 = 10% ready, 2 = 20% ready, 3 = 30% ready, 4 = 40% ready, 5 = 50% ready, 6 = 60% ready, 7 = 70% ready, 8 = 80% ready, 9 = 90% ready, 10 = 100% ready.

The assessor should add the scores for each part together to get the total scores. After that, the assessor may use the total score to calculate the readiness level for each part. In addition, to calculate the overall score for the municipality, the assessor should add all the scores together to get the total. Alternatively, the assessor may add all the total scores together to get the overall score for the municipality. Therefore, the assessor may determine the readiness level for each part by using the formulas listed below:

1) Formula to calculate human readiness level (HRL):
$$\boldsymbol{HRL}=(Human\ readines\ total\ score\ \div\ 60)\ \times 100$$
2) Formula to calculate technological readiness level (TRL):
$$\boldsymbol{TRL}=(Technological\ readiness\ total\ score\ \div\ 100)\ \times 100$$
3) Formula to calculate organizational readiness level (ORL):
$$\boldsymbol{ORL}=(Organisational\ readiness\ total\ score\ \div\ 90)\ \times 100$$
4) Formula to calculate environmental readiness level (ERL):
$$\boldsymbol{ERL}=(Environmental\ readiness\ total\ score\ \div\ 70)\ \times 100$$

To calculate the municipality readiness level (MRL), the assessor may use the following formulas:

$$\boldsymbol{MRL}=\frac{(HRL+TRL+ORL+ERL)}{4} \qquad \text{OR}$$

$$\boldsymbol{MRL}=(Overall\ score\ \div\ 320)\ \times 100$$

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The following heuristic is proposed to evaluate the readiness level and indicate the way forward: If the municipality readiness level is between 0% and 50%, it will mean the municipality is not at all ready, overall unprepared, and extensive work must be done to get ready. When the municipality readiness level is between 51% and 74%, it still means the municipality is not yet ready for implementation and considerable work has still to be done. If the municipality readiness level is at 75% or more, a municipality may be considered almost ready but will require a few improvements. The municipality might start implementing a smart city while improving those areas that are not yet ready. At 100%, the municipality is completely ready and could start implementation without any further preparatory intervention needed.

Below is the finalized assessment tool (see Table 2). Although the assessment tool has been evaluated and validated, as discussed above, it could be tested further in future studies by practically applying the assessment tool in at least three small and rural municipalities. Comparing and evaluating the results could confirm the accuracy of the assessment tool, the formula to calculate the readiness score and the heuristic to evaluate the readiness level, or to prompt additional refinements.

For each statement, select "Yes" if you agree or "No" if you disagree in the third column. Enter the number that best represents your municipality's readiness in the fourth column. The scores are interpreted as follows: 0 = 0% ready, 1 = 10% ready, 2 = 20% ready, 3 = 30% ready, 4 = 40% ready, 5 = 50% ready, 6 = 60% ready, 7 = 70% ready, 8 = 80% ready, 9 = 90% ready, 10 = 100% ready.

Table 2. A Finalized Assessment Tool to Assess Small and Rural Municipalities' Readiness for Smart City Implementation

No.	Human readiness	Yes/No	Score (0-10)	Comment
1	There are citizens in this municipality with the relevant educational qualifications for smart city implementation.			
2	There are citizens in this municipality with the relevant experience to develop a smart city.			
3	There are innovative citizens in this municipality who can contribute to the development of smart city implementation.			
4	The citizens in this municipality possess the required skills to implement a smart city.			

5	The citizens in this municipality are in support of smart city development.		
6	There are enough people with the relevant technical skills in this municipality to contribute to the implementation of a smart city.		
	Human readiness total score		
	Technological readiness	**Enter a score between 0 and 10**	**Comment**
7	There are relevant social, physical, and economic infrastructures within this municipality.		
8	Modern technologies required for smart city implementation are available within this municipality.		
9	The modern infrastructure required for smart city implementation is available within this municipality.		
10	The available modern technologies are compatible with the municipality's existing infrastructure for smart city implementation.		
11	Vendors of modern technologies and infrastructure are available and accessible within this municipality.		
12	Modern technologies and infrastructure are affordable.		
13	The available technology and infrastructure are suitable for collecting and analyzing data in real-time.		
14	The analyzed data will provide the municipality with the information for decision-making in real-time.		
15	The infrastructure supports internet connectivity.		
16	The available technology and infrastructure are secured.		
	Technological readiness total score		
	Organizational readiness	**Enter a score**	**Comment**

		between 0 and 10	
17	The municipality management supports you as a municipality in implementing a smart city.		
18	You have support from politicians for a smart city project.		
19	The municipality has partnerships with the public and private sectors.		
20	There are employees with the relevant educational qualifications for smart city implementation.		
21	There are employees with the relevant experience to develop a smart city.		
22	There are employees with the relevant technical skills to implement a smart city.		
23	The municipality has the required resources to implement a smart city.		
24	This municipality generates 50% of its revenue.		
25	There is a budget to fund smart city initiatives.		
	Organizational readiness total score		
	Environmental readiness	**Enter a score between 0 and 10**	**Comment**
26	There is a reliable internet connection within the municipality.		
27	You have reliable and sustainable energy.		
28	Policies support smart city development in the municipality.		
29	The municipality personnel and citizens comply with the policies to promote good governance.		
30	You have buy-in from traditional leaders.		
31	You have a strong economy to ensure smart city development.		

32	There are buildings that are capable of collecting data without human intervention.	
	Environmental readiness total score	
	The overall score for the municipality's readiness: (To calculate the overall score, calculate the overall total of all the scores or total scores above.)	

4.6. Discussion

The overall findings of this study present distinct challenges that are experienced by small and rural municipalities in developing smart cities. Therefore, the findings stressed the need for a tailored tool that can be used to assess small and rural municipalities' readiness for smart city implementation. This is in line with Berst [60] and Desdemoustier et al. [50] showing that an assessment tool or framework must be context-specific for it to be easily usable. Traditional frameworks or tools used to assess smart city readiness are not one size fits all; these include frameworks like the Technology, Organization, and Environment (TOE) model [60] and similar generic tools meant for urban municipalities [42], [61], [62].

The final version of the assessment tool that was developed integrates contextual measures that are specific to small and rural municipalities. Those indicators encompass human [63], technology, organization, and environment [40], [64]. The findings support earlier research findings with the participants acknowledging the availability of human, technology, organization, and environmental readiness factors in the assessment tool. The literature and participants concurred that all these areas had to be ready to implement the smart city concept successfully.

Comparing the results of this study with existing frameworks like the Smart Readiness Indicator (SRI) [65], Smart City Interoperability Framework [66], makes it clear that they focus on the technological, environmental and organizational aspects while ignoring the human aspects, such as the role of traditional leadership in developing a smart city. Having a multidimensional assessment tool that incorporates human, technological, environmental and organizational readiness factors bridges the gaps that were identified in the existing literature in assessing small and rural municipalities' readiness for smart city implementation. The findings of this study further suggest that a holistic readiness assessment tool, as depicted in Table 2, is important in overcoming unique challenges that are faced by small and rural municipalities. The developed assessment tool is aligned with the unique needs of small and rural municipalities in ensuring that they address their specific readiness gaps in implementing a smart city.

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5. CONCLUSION

The main aim of this study was to develop an assessment tool for assessing small and rural municipalities' readiness for smart city implementation. To achieve this aim, the study employed a design science research approach to guide the development of the assessment tool. The researcher collected data in three iterations to ensure the validity of the developed assessment tool to assess small and rural municipalities' readiness for smart city implementation. During the first iteration, data was collected through face-to-face semi-structured interviews from five small and rural municipalities in three different provinces in South Africa. The interview data were analyzed using thematic analysis on ATLAS.ti. Three themes were identified, and the findings and discussions were presented. An assessment tool was developed based on the interview data. The assessment tool was evaluated and validated using online survey data. Based on the feedback received during the validation, the assessment tool was revised into its final form as the finished artefact. This assessment tool is crucial for ensuring that small and rural municipalities are prepared before they engage in smart city projects. Assessors in small and rural municipalities may use the developed assessment tool to measure municipality readiness before they engage in smart city projects. Furthermore, it will assist in guiding the decision makers when allocating resources and for stakeholder engagement. On the other hand, this framework may assist small and rural municipalities to identify areas that need improvement. Future studies should implement the assessment tool practically in three municipalities and determine its feasibility, accuracy and usefulness on the ground.

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