Extending the "Smart City" Concept to Small-to-Medium Sized Estonian Municipalities: Initiatives and Challenges Faced

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Abstract. This study investigated smart city initiatives and challenges faced by small to medium sized municipalities. The literature on smart cities is dominated by findings from large cities yet, both large and small municipalities are expected to contribute towards the fulfillment of the United Nation's 17 sustainable development goals. A mixed method was used in which 35 municipalities were engaged. Study findings suggest that rural municipalities are yet to be fully aware of how they can harness the technology and become smart in the way they operate and serve inhabitants. Nonetheless, cities and towns seem to have an idea of what smart city initiatives to consider. Together, Estonian cities, towns and rural municipalities face several challenges in their efforts to assume "smartness" something that needs to be addressed in a pragmatic way. Municipalities face unique challenges; hence, solutions that work for one municipality may not work for another.

Keywords: Digital Governance · Smart City · Smart Village · SDGs · ICTs

1 Introduction

The United Nations (UN) estimate that more than 50% of the world population is based in cities that occupy 3% of the earth's surface [1–4]. This population in cities and towns (urbanization) is expected to increase to approximately 66% by 2050 due to birth, migration from rural areas or as new urban settlements are established. There are concerns that the continued population growth will make urban areas difficult to manage while at the same time depleting limited resources that are meant to service the present and future generations. The UN and the European Union (EU) have endorsed the smart city concept as a panacea for managing urban settlements and promoting a sustainable use of resources [1, 2]. The use of disruptive, cutting-edge Information and Communication Technologies (ICTs), Internet of Things (IoTs) and big data analytics are among other technological solutions that are expected to derive the smart city concept [1] and small to medium sized municipalities are also expected to benefit from such

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initiatives [5]. However, little is known about challenges faced by small to medium sized municipalities in their endeavor to adopt and use these technologies. Solutions for smart city initiatives are often developed in big cities that have socio, economic and demographic characteristics that are not consistent with those of small municipalities [5]. Thus, factors that enable the development of a smart city such as, high population density, a big service sector and high productivity are not common in small municipalities [6, 7], yet such locations are also expected to succeed in technology adoption and use [5]. Besides, the smart city concept involves digital transformation that will see the adoption of radical and disruptive technologies that are complex with no pre-defined processes [2, 8]. Hence, this study explores challenges faced by small to medium sized municipalities as they adopt the smart city concept. The study uses findings from pilot research that was conducted on Estonian municipalities.

2 Literature Review

2.1 Smart City Concept

The use of the phrase "smart city" can be traced back to the 1990s when cities started to use ICTs for different purposes such as in electronic government (e-Government) [9, 10]. Today, the smart city concept has become a global phenomenon that is expected to play a pivotal role towards the fulfilment of the UN's 17 sustainable developmental goals (SDGs) by 2030 [1, 10, 11]. Besides, a city that is resilient, safe, inclusive, and sustainable is one of these SDGs [1, 10]. Wang, Luo, Zhang and Furuya [12] goes on to suggest that the desire to attain sustainability through smartness is not specific to cities alone but to all communities including rural areas. Accordingly, the need to attain the 17 SDGs has seen more research effort put in understanding and conceptualizing the smart city concept to all communities – large, small and marginalized communities – as seen with the recent use of phrases such as "smart villages" [1, 4, 12, 13].

Despite all this popularity, there is no single smart city theoretical explanation or definition [4, 10]. For example, the European Commission defines a smart city as a place where the efficacy of traditional networks and services is enhanced by using digital technologies and/or ICTs in a manner that benefit inhabitants and businesses [2, 10]. The European Commission adds that the smart city concept goes beyond the use of ICTs but can also mean "smarter urban transport networks, upgraded water supply and waste disposal facilities and efficient ways to light and heat building", "a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population" [10]. In addition, Ismagilova, Hughes, Dwivedi and Raman [11] proposes that smart cities are cities that "use an Information Systems centric approach to the intelligent use of ICT within an interactive infrastructure to provide advanced and innovative services to its citizens, impacting quality of life and sustainable management of natural resources". All these definitions point towards improving the quality of life and simplifying the way communities are managed [4, 10, 12].

2.2 Smart City Initiatives and Challenges

The literature identifies different areas where the smart city concept is applicable [14]. For example, in large cities where the use of smart cities is dominant, it is used (smart

city initiatives) to improve the lives of inhabitants and manage resources through smart mobility or smart transportation, smart living (public safety and smart buildings), smart environment, smart citizens, smart economy, smart government, and smart architecture and technologies [11, 12]. Successful implementation of these smart city initiatives requires the formulation of a smart city strategy, setting up governance structures, implementing supporting technologies, and identifying and engaging all relevant stakeholders [2, 14]. Furthermore, a community that is adopting a smart city concept must exhibit the following characteristics: high population density, proximity to a big city/be a big city, low remoteness, low unemployment, high productivity, high employment in a service sector and the availability of local university [6, 7]. Successfully harnessing the smart city concept will result in social, economic, and environmental sustainability [10].

However, characteristics for enabling smart city initiatives are not consistent with those of small to medium sized municipalities. For example, Estonia has a population of 1.3 million, 79 sparsely populated municipalities of which 75 municipalities have a population of less than 50,000 [5]. The European Commission classify communities with 10 000 to 100 000 residents as small municipalities. Hence, such municipalities do not meet some of the key requirements for successfully harnessing the smart city concept. Despite being small in nature, marginalized and lacking resources, the EU policy recognize that such communities must attain "smartness" in the way they serve inhabitants and manage resources [16]. There is ongoing debate on whether these small municipalities should assume a scalable approach and equally apply smart solutions developed for bigger cities while others argue that small municipalities have distinct features that warrant a unique set of solution for smartness [12, 16–18]. Regardless of the approach assumed, these small to medium sized municipalities will need to adopt cutting edge technologies that will be used as a means for realizing better quality of life for residents and sustainability [12]. Given the prevailing contextual characteristics of small municipalities, these municipalities are expected to face a number of challenges when harnessing technologies for "smartness" given the vast amount of technologies that need to be considered such as big data, artificial intelligence, IoTs, cloud computing, data analytics and ICTs [1, 2, 10, 11]. The often-reported challenges relate to funding, heterogeneous devices and disintegrated systems, lack of capacity, big data management, information security and, social awareness and acceptance [14, 19–22]. These challenges are discussed below.

Funding: Small to medium municipalities tend to have little financial resources for implementing a smart city concept [5] as they are mostly dominated by less productivity and are often agriculture-based [17]. Those aspiring to adopt a smart city concept need to pay for designing, hardware and software, operational and maintenance costs. According to Silva et al. [21], designing costs are related to the initial capital outlay for deploying a smart city. This is followed by the costs for acquiring the necessary hardware and software that includes IoTs and ICTs infrastructure [20]. For example, London invested in 5969 public Wi-Fi hotspots across the city and spent approximately USD 2.32 million on indoor public Wi-Fi for Galleries and Museums [1]. Furthermore, there are operational costs for the day-to-day running of a smart city and maintenance costs that also requires funding. The EU and other international or local organizations offer funding for smart city initiatives as these are seen as funds for infrastructural improvements. For instance,

Helsinki receives funding from the EU for performing pilot testing and experimental tests on smart city research projects [2]. However, Hämäläinen [2] goes on to note that the uncertainty of smart city funding necessitates self-funding as done by Helsinki.

Heterogeneous Devices and Disintegrated Systems: The architecture of a smart city is composed of heterogeneous devices and appliances from different vendors that perform a wide range of services [21, 22]. These multi-devices often have incompatible platforms something that make the setting up of a smart city complex and difficult, requiring numerous rounds of pilot testing and experimentations. Furthermore, city data is often gathered within different departments or domains using unique ICTs that are specific to these domains [2]. As such, becoming a smart city is down to the ability of integrating different technologies into one central processing location [21, 22]. Bibri and Krogstie [1] notes that Barcelona's Sentilo and City OS platforms provides a good example of how a city can setup a horizontal information platform that aggregates and standardize open data from heterogenous devices. Barcelona and London, some of the success stories in this area, integrate data from different departments and present this in real-time using visualizations on a dashboard in operation centers [1, 21]. Cities often engage technological companies and research institutes when searching for solutions on integrating heterogenous devices and disintegrated systems for smart cities [2, 21]. However, approaches assumed in London and Barcelona cannot easily be transferred to small municipalities given their lack of resources and supportive institutions [17].

Lack of Capacity: Municipalities lack the capacity to deliver technology driven solutions [20] especially small to medium sized municipalities. This include a lack of skills and expertise to effectively harness the technology in a way that is consistent with expectations of smart city initiatives – sustainability and improving the quality of life. The literature suggests that municipalities need to establish an ICT department that is responsible for all technologies that facilitate smart city concept as done by the Finish capital Helsinki [2]. Furthermore, cities engage the private sector when developing new technological solutions for smart city initiatives as revealed by Helsinki City that works with a private organization, Forum Virium Helsinki (FVH) Ltd., for experimenting new technological solutions [2]. According to Silva et al. [21], London's ability to establish an infrastructure to support smart city initiatives is down to the city's engagement with research institutes, among other collaborations. In addition, new academic programs have been developed to equip people with skills for managing the city using big data analytics [1]. Most of these solutions have been found applicable to big cities but they are hardly compatible with rural municipalities, for example, where there is a lack of digital literacy, depopulation, and less connectivity [12, 17].

Big data Management: Smart city initiatives are faced with a challenge to manage a huge amount of data that is continuously generated by countless devices [19, 21]. This heterogeneous data from different devices needs to be collected, stored and processed in seamless operations of the city something that presents a huge challenge [21]. Managing big data is expected to be a huge challenge for small to medium sized municipalities given their lack of resources especially supporting infrastructure and digital skills [12, 17]. However, if successfully managed, this data can be used to support the development of

various data driven innovation solutions for smart cities as shown in London, Singapore, Helsinki and Barcelona [1, 10, 21, 23]. Bibri and Krogstie [1] notes that London and Barcelona are among the first European cities to use data driven applications to improve the lives of citizens.

Social Awareness and Acceptability: There are suggestions that inhabitants may not be privy to smart city technological initiatives for them to accept their use [20]. Even when aware, citizens may still decide against using smart city solutions for different reasons. For example, Bielska et al. [17] notes that rural municipalities lack openness and involvement. Bawany and Shamsi [19] goes on to suggest a need to change social habits and the mindset of inhabitants so that they embrace the use of the technology. For better social awareness, the city of Helsinki made its services accessible using a "one-stop shop" application known as "Service Map" [2]. In addition, there are initiatives for crowd sourcing that aim to engage citizens in addressing city problems. In some cases, citizens are given mechanisms to provide feedback and rate service provision by the city with the intent of using this information to shape service delivery according to citizen' needs [21] something that may promote acceptance. This is complemented by educating citizens to improve their technical skills for easy interaction with various smart city technologies [1].

Information Security: Smart city applications rely on gathering personal and sensitive data from citizens using different sets of infrastructure [14, 21, 22]. Thus, smart cities gather data on citizens from heterogeneous devices that operate on unique platforms something that present a security challenge. In addition, there can be no guarantees that all individuals will be security cautious when accessing smart city applications in an environment where attackers have become more skillful. Hence, there is need for a security framework that protect the smart city infrastructure, the privacy and confidentiality of user data [21]. This data needs to be protected during collection, storage, processing, and dissemination [14, 19]. Interestingly, the available solution for aiding information security such as compliance with the General Data Protection Regulation (GDPR) of Europe is seen as a huge challenge for municipalities [2].

3 Research Methodology

This study is based on a combination of mixed methods. The assortment included a questionnaire, individual interviews and several workshops with multiple Estonian municipalities. This data was gathered from a pilot project of the idea competition of the Smart City Center of Excellence of the FinEst Twins [24]. The mayor, deputy mayor, development specialists and other experts from municipalities took part in this study. Initially, a questionnaire was sent out to 35 Estonian municipalities. This questionnaire helped to map the most pressing issues of cities, towns, and municipalities. Those who participated in questionnaires (16 Municipalities) were further engaged through interviews to gain an understanding of the nature and magnitude of the challenges faced. This study report findings from interviews. These interviews clarified all the doubts the participant had regarding the questions and collected more elaborated answers on the challenges faced. Thematic analysis was used to analyze the data.

4 Results

Sixteen cities, towns, and rural municipalities were engaged in data collection using interviews. Of these municipalities, 7 are classified as towns followed by 5 rural municipalities and 4 cities. The biggest city, in terms of population, in this study – Tallinn city – has a population of 0.5 million while the remaining three cities have population ranging between 50000 and 94000 inhabitants. The researched Estonian towns shows to be small with an average population of 10500 inhabitants. Lastly, rural municipalities that were engaged in this study have an average population of 16000 inhabitants. Furthermore, an average of four participants were interviewed per municipality.

4.1 Smart City Initiatives

Current Smart City Initiatives: Study findings suggest that there are ongoing smart city initiatives in some of the researched Estonian municipalities. For example, the government city of Võru is involved in a ***smart environment*** initiative by adopting an automated data management system for managing the energy of real estates. Similarly, a move to have an open and transparent government by conducting online municipality meetings that are open to residents, for example, suggest the use of a ***smart government*** by the town of Valga. Furthermore, there are suggestions of various ***smart living*** initiatives being practiced in Jelgava. For example, sensors installed on rivers are used to gather data on water level. This data is then used in flood notifications to those who reside along the riverbanks. Sensors have also been placed on roads to gather data on ice locations so that snow clearance is done on a need basis. In addition, ***smart living*** is also visible in Jelgava city's use of sensors to monitor climate and the level of carbon dioxide in schools and other public buildings. In this case, data driven decisions of taking lesson breaks and opening windows are assumed if the level of carbon dioxide is too high. Furthermore, Jelgava uses a ***smart transportation*** system as evidenced by traffic lights whose functionality is determined by the flow of traffic rather that predetermined timeslots.

Plans on Smart City Initiatives: Participants were asked to indicate digital solutions that should be implemented in their city by the year 2025 or 2030. The gathered data shows an inclination towards digitalization with the intent of using data driven solutions where IoTs are among the technologies to be used. For example, a participant from Tallin city stated that they expect to be able to visualize data that is gathered using sensors by the year 2025. Expectations are that service delivery will be data driven where real-time feedback from inhabitants will be used to improve city services. In particular, selected Estonian cities, towns and rural municipalities expect to use big data for smart transportation, smart environment, smart living, and smart governance. With reference to smart transportation, the idea is to *have "a self-managing public transport system which enables multimodal mobility that can be completely customized for a person's needs in real time"* or "*smart and remote-controlled traffic management fixtures that enable flexible adjustments of traffic management and support the use of V2X technology. [Furthermore,] a solution for analyzing and modelling traffic [is also required]."* Smart environment initiatives include the use of data to monitor carbon dioxide in the city and

"*monitoring energy consumption in real time"* and managing each building's energy consumption.

In addition, a participant from Rakvere town suggested that the town plans to implement smart living initiatives as it was stated that they hope for a "*wider application of the digital solutions in the city's social, cultural, and educational system and in tourism"*. Similarly, suggestions for smart government initiatives were identified from the gathered data. For instance, a participant from Tartu city suggested more use of electronic services (eServices) as it was stated that "*all public services should be available as electronic and mobile services"* and using "*a document management system that allows [one] to monitor the processing of applications"*. Similarly, a participant from Rakvere states that the use of "*smart integrated governance of the city government"* or using "*a system of indicators on governance to monitor different domains"* as stated by a participant from Saaremaa rural further suggest intentions for smart government initiatives. Furthermore, a participant from Valga town suggests the use of crowdsourcing to receive reports of faults by stating that "*a system for residents to notify the local government of [current] problems [should be implemented by 2025]"*.

4.2 Challenges Faced by Municipalities

Participants were asked to describe problems their city/rural municipality must address in the next 5 to 10 years. A list of 10 challenges were arrived at following discussions and a challenge-based workshop. The participants, 35 local governments, collectively made some changes to the list of top 10 problems that Estonian cities, towns and rural municipalities are facing when solving these in a smart way. While the Smart City Center of Excellence of the FinEst Twins solely focused on challenges that relate to transport, energy, built environment, governance, and data [24]; this study focuses on findings that are specific to governance and data challenges. Participants indicated that the most common challenges relate to the lack of capacity, data specification and accessibility, big data management, lack of system integration, setting up the infrastructure, information security and big data usage. The nature and extent of these challenges is presented next.

Lack of Capacity: Participants cited several issues that relate to the lack of capacity to manage big data. These concerns were raised by participants from six towns, two cities and three rural municipalities. For instance, there is evidence of lacking skills to use big data as participants describe their lack of knowledge on what kind of data and for what purpose must data be gathered. In addition, certain information is being collected, and its volume is constantly increasing something that further complicate the situation as explained by a participant from Tartu city: "*The precise need and extent of data collection is undetermined, i.e., who needs what kind of data. At the same time, we are collecting increasing amounts of information"*. The technical capacity and competency for data processing, analysis, and using big data for governance decisions is also lacking. A participant from Tartu city explains that "*today, the capacity to process and analyze information and use it for governance decisions is small and we have no necessary technical solutions"*. Another participant from the same city also stated that: "*The city of Tartu has never had a Head of Data Management. This is why the situation is somewhat*

chaotic…. We have discussed hiring a manager for information issues." The lack of human resources with the necessary skills for smart city initiatives were also emphasized by another participant: "*We do not have enough employees who would assemble various data into a single database to improve our administrative capability and the quality of public services"*.

Data is Not Specific and Accessible: Empirical evidence suggests that cities, towns and rural municipalities mainly rely on data that is captured by Statistics Estonia. However, this data is often not specific to the needs of municipalities. One of the participants explains that: "*Statistics Estonia does not issue a separate set of data for Pärnu alone"*. Instead, the data is generalized at country level. Another participant from Lääne clarifies this challenge: *"…A lot of the essential information is collected for the entire county, not for individual rural municipalities… For example, when preparing a public health profile, the data input is available on the county level, but the population profile varies so wildly within the Harju County that it does not characterize the situation in our rural municipality"*. Thus, statistics at national level are seen to be too biased towards big cities at the expense of rural municipalities as further comments highlighted that: "*[in] the example of the health profile: county-level data is not accurate enough – the city of Tallinn and the Golden Circle influence it too much"* such that interpretations of the data will be biased towards the cities.

Another challenge is that data is not availed in real-time or when needed. "*The state releases information with a delay that is too long for the data to be used as a basis for plans. We need information about this summer to plan for the next, not information about the summer two years ago."* Similar views were shared by a participant from Saaremaa rural municipality: "*As it stands, we have cooperated with Statistics Estonia, but do not have access to the required information at the necessary time to monitor all the aforementioned areas."* In addition, the private sector does not have direct access to data. Often, the private sector must engage the municipality to have access to data according to a participant from Tartu: "*Most of the collected information is still not accessible as open data. When we have received specific requests for information from the private sector, we have tried to accommodate"*.

Big Data Management: Participants from different cities and towns cited challenges that suggest difficulties with the management of big data. There appears to be a lack of data standardization and challenges on publishing or organizing data. With reference to data standardization, a participant from the city of Tartu suggested that there is no clarity on what type and format of data needs. Furthermore, there is a lack of knowledge on the value of data to target groups such that the information is availed to the intended users; hence, the need for data standardization. The challenges on publishing or organizing data were raised by participants from Võru town and Tallinn city. For instance, questions were raised on what information should the municipality publish and how this can be done in a more dynamic manner. Focus is on visualizing all the important data in a user-friendly format that could give room for personalized data use by different user groups – residents and city officials. Thus, "*[to] provide information [data] to citizens and organizations that they could use at their discretion and for the creation of new services"*. This challenge is exacerbated by the increasing volume of data thereby making it difficult for residents

to find the actual data they want. A participant from Tartu city explained that "*due to increasing information volumes, the residents find it more complicated to organize their daily lives and find information about services that are important to them"*. Lastly, there is also a need to consider data requirements for the old population that is not always friendly to the technology: "*the 85+ population is increasing, and we have to consider their needs."*

Lack of System Integration: Study findings suggest that cities, towns and rural municipalities face challenges related to a lack of system integration. For example, there are suggestions that some of the data is not available digitally especially data on old files. Even when this data is digitized, there are concerns that the databases are not physically connected something that promote information silos. For example, a participant from Rae rural municipality noted that databases in use are incompatible "*our problem is that different databases are not compatible"*. This is supported by a finding that local governments have individual, need-based systems as stated by a participant from Pärnu city "*every municipality builds a separate system"*. This calls for systems that can collect information from various databases or physically connected databases. This view was shared by a participant from Tallinn city "*[there is a need to] establish data bridges with neighboring municipalities and the urban region of Helsinki to integrate data-based governance, cooperation, and services"*.

In addition to having physically connected databases, the stored data must be compatible with different databases and the data should have "*interlinking"* keywords that make the extraction of related information from different databases easy. A participant from Rae rural municipality stated that *"an important issue is submitting data in a format that would allow it to be used more widely and to be added to different databases. Our goal is to have keywords in documents that help us find and link different information"*. Failure of which, a participant from Valga town explained the cost implications of a disintegrated systems to municipalities that are tasked with the responsibility of providing social and educational services to residents: *"[if] we do not know where people who consume our services live. A person could be an officially registered resident in Estonia and receive benefits [in Valga] while living in Latvia."* Thus, information about a municipality's population is key when allocating resources for service delivery where "*social services and education are the biggest expenses for the municipality"*.

Setting up the Infrastructure: Study findings suggest that municipalities are faced with a challenge of setting up the infrastructure and services for enabling data driven solutions in governance. As reported by some participants, there is need for more electronic and mobile services to be set up: "*public services should be remotely accessible as much as possible; however, this is currently not the case. We need consistent development of electronic and mobile services"*. This infrastructure should enable linkage between different service domains, departments and facilitate communication across municipalities. IoTs sensors are among the devices to be setup as one of the participants indicated that: "*It would be great if we could install various sensors in the rural municipality that would provide data in real time. We would like to monitor the energy consumption of buildings and devices and control the temperature in buildings from a distance. For us, improving communication with Latvia is extremely important because many residents*

of the Valga rural municipality and people working here are Latvian citizens". Furthermore, there are suggestions for other IoT technologies that need to be set up in different locations within the municipality. For instance, there is a need for security cameras in the public space, sensors on rivers to gather data on water level and sensors on roads for gathering data on ice and using smart traffic lights.

Information Security: The modern information society needs to contribute more towards Information Technology (IT) security and data protection. Currently, navigating data protection, the GDPR, and cybersecurity regulations is difficult for local governments. These views emanated from the gathered data as it was stated that "*in the modern information society, our IT security (ISKE) and data protection need increasing investments"*. Similarly, a participant from Rae rural municipality suggested that complying with the data protection act is another problem that need to be resolved as it was stated that "*another important issue is complying with the requirements for data protection."* Similar views on ensuring information security were shared by a participant from Tallinn city: "*data management must be based on a clear principle that a resident's information belongs to them and we must guarantee lawful and secure data management"*.

Big Data Use: Study findings suggest a slow adoption and use of big data in decision making. Thus, even though the municipalities are gathering data that is important for decision making, these municipalities do not go on to use the data for decision making. This is emphasized in feedback that was given by a participant from Elva town who stated that "*we collect a lot of data but do not use it much when making decisions. We mostly 'follow our guts'"*. It is not clear if this is related to a lack of capacity or just a traditional practice.

5 Discussion and Conclusion

This study investigated challenges associated with digitalization when small to medium sized municipalities are adopting a smart city concept. The literature on smart cities is mainly focused on the success stories of leading adopters with little focus paid on small cities and towns. Interestingly, the smart city concept is regarded as one of the solutions for meeting the 17 SDGs, goals that should be met by both cities, towns and rural municipalities. Study findings showed that Estonian cities and town municipalities are engaged in various smart city initiatives such as smart transport, smart living, smart government, and smart environment. These cities and towns are also keen on using various technologies, emerging technologies included, to attain a smart city status. Nonetheless, little data emanated from the engaged rural municipalities on what smart initiatives they are currently and plan to implement. Rural municipalities that showed interest in the smart city or smart village appear to be emulating what is being done in large cities and towns. Otherwise, a participant from Rae rural municipality appear to summaries the general status of smart village adoption by stating that *"so far, we have concentrated on smaller things that definitely function. We would need a huge leap…"*. These findings suggest a void in the implementation of smart city or smart village initiatives in rural municipalities given that the smart city concept has been dominated by large cities [12,

17]. It can be said that rural municipalities are struggling to conceptualize "smartness" within their context hence the need for more research on how such areas can best benefit from the use of technology.

Furthermore, study findings shows that municipalities face several challenges that include the lack of capacity, data specification and accessibility, big data management, lack of system integration, setting up the infrastructure, information security and big data usage. For example, there is a lack of knowledge on the kind and purpose of data that must be gathered, a lack of technical capacity and competency to collect, process, analyze and use data in decision making. The literature suggest that such challenges can be resolved by pilot testing smart city solutions, training users and establishing a department that is dedicated to ICT issues and/or engaging local research institutions and technological companies [1, 2, 21]. These suggestions appear more suited for large towns and cities that have a better service sector according to study findings by Duygan et al. [6] and Yigitcanlar et al. [7]. In this study, the town of Rakvere is taking advantage of a better service sector by working with the University of Tartu in developing a solution that uses satellite data in developing and planning cities. Viimsi rural municipality shows the use of a private sector organization, KPMG, in assessing the implementation of its information systems. However, a small service sector in rural areas suggest that rural municipalities are exposed to a limited base for consultations when compared to their counterparts. Furthermore, challenges faced by rural municipalities are compounded by the lack of relevant reference case studies on how such municipalities can successfully harness the smart village concept. This points to the need of a bottom-up approach when adopting the smart city or smart village concept. The use of a bottom-up approach in implementing smartness across cities, towns and rural areas is supported in the literature [5, 12, 17, 18]. It is important to point out that this study findings suggest a top-down approach is being used to implement the smart city concept. For example, Statistics Estonia appears to be the central organization that gathers and disseminate data to different municipalities. This data appears to be limited and does not meet all the information needs of municipalities as mentioned by participants from Lääne and Rae rural municipality. Again, a participant from Valga town further emphasizes the need for a localized solution for implementing a smart city solution by reporting challenges faced due to towns and cities' system disintegration. The current system does not seem to permit the collating of different forms of data across cities, towns and rural areas as required by municipalities. On the other hand, it is accurate that small municipalities lack resources (skills and human resources) something that may warrant a top-down approach to implementing smartness. However, if assumed, such an approach should be based on a facilitative role otherwise this may result in biased initiatives that do not conform to interests of the intended target/rural areas [16].

Study limitations and Future Research: The current study combine views of cities, towns and rural municipalities, and went on to consolidate the most common challenges. While this approach identified the most important challenges, it may have unintentionally disregarded concerns from rural municipalities as these have unique characteristics compared to those of cities and towns. Hence, more research effort is needed on challenges faced by rural municipalities and how they can assume "smartness" within their contexts.

References

1. Bibri, S.E., Krogstie, J.: Smart eco–city strategies and solutions: the cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden. Urban Sci. **4**(1), 1–42 (2020)
2. Hämäläinen, M.: A framework for a smart city design: digital transformation in the Helsinki smart city. In: Ratten, V. (ed.) Entrepreneurship and the Community. CMS, pp. 63–86. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-23604-5_5
3. Shao, Q.G., Jiang, C.C., Lo, H.W., Liou, J.J.: An assessment model of smart city sustainable development: integrating approach With Z-DEMATEL and Z-TOPSIS-AL (2022)
4. Wirsbinna, A., Grega, L.: Assessment of economic benefits of smart city initiatives. Cuadernos Econ. **44**(126), 45–56 (2021)
5. Agriesti, S.A.M., Soe, R.M., Saif, M.A.: Framework for connecting the mobility challenges in low density areas to smart mobility solutions: the case study of Estonian municipalities. Eur. Transp. Res. Rev. **14**, 32 (2022)
6. Duygan, M., Fischer, M., Pärli, R., Ingold, K.: Where do smart cities grow? The spatial and socio-economic configurations of smart city development. Sustain. Cities Soc. **77**, 103578 (2022)
7. Yigitcanlar, T., Kenan, D., Luke, B., Kevin C. D.: What are the key factors affecting smart city transformation readiness? Evidence from Australian cities. Cities **120** (2022)
8. Kutty, A.A., Kucukvar, M., Abdella, G.M., Bulak, M.E., Onat, N.C.: Sustainability performance of European smart cities: a novel DEA approach with double frontiers. Sustain. Cities Soc. (2022)
9. Bibri, S.E.: A novel model for data-driven smart sustainable cities of the future: the institutional transformations required for balancing and advancing the three goals of sustainability. Energy Inform. **4**(1), 1–37 (2021)
10. Shamsuzzoha, A., Nieminen, J., Piya, S., Rutledge, K.: Smart city for sustainable environment: a comparison of participatory strategies from Helsinki, Singapore and London. Cities **114**, 103194 (2021)
11. Ismagilova, E., Hughes, L., Dwivedi, Y.K., Raman, K.R.: Smart cities: advances in research—An information systems perspective. Int. J. Inf. Manage. **1**(47), 88–100 (2019)
12. Wang, Q., Luo, S., Zhang, J., Furuva, K.: Increased attention to smart development in rural areas: a scientometric analysis of smart village research. Land **11**(8), 1362 (2022)
13. Bibri, S.E., John, K.: A novel model for data-driven smart sustainable cities of the future: A strategic roadmap to transformational change in the era of big data. Future Cities Environ. **7**(1) (2021)
14. Eckhoff, D., Wagner, I.: Privacy in the smart city—applications, technologies, challenges, and solutions. IEEE Commun. Surv. Tutor. **20**(1), 489–516 (2017)
15. Hämäläinen, M., Tyrväinen, P.: Improving smart city design: a conceptual model for governing complex smart city ecosystems. In: Bled eConference. University of Maribor Press (2018)
16. Szalai, Á., Varró, F., Szabolcs, F.: Towards a multiscalar perspective on the prospects of 'the actually existing smart village'–a view from Hungary. Hung. Geogr. Bull. **70**(2), 97–112 (2021)
17. Bielska, A., Stańczuk-Gałwiaczek, M., Sobolewska-Mikulska, K., Mroczkowski, R.: Implementation of the smart village concept based on selected spatial patterns–a case study of Mazowieckie Voivodeship in Poland. Land Use Policy **104**, 105366 (2021)
18. Cowie, P., Leanne, T., Koen, S.: Smart rural futures: will rural areas be left behind in the 4th industrial revolution? J. Rural. Stud. **79**, 169–176 (2020)
19. Bawany, N. Z., Shamsi, J.A.: Smart city architecture: vision and challenges. Int. J. Adv. Comput. Sci. Appl. **6**(11) (2015)

20. Khan, H.H., et al.: Challenges for sustainable smart city development: a conceptual framework. Sustain. Dev. **28**(5), 1507–1518 (2020)
21. Silva, B.N., Khan, M., Han, K.: Towards sustainable smart cities: a review of trends, architectures, components, and open challenges in smart cities. Sustain. Cities Soc. **38**, 697–713 (2018)
22. Zhang, K., Jianbing, N., Kan, Y., Xiaohui, L., Ju, R., Xuemin, S.S.: Security and privacy in smart city applications: challenges and solutions. IEEE Commun. Mag. **55**(1), 122–129 (2017)
23. Chen, Y., Silva, E.A.: Smart transport: A comparative analysis using the most used indicators in the literature juxtaposed with interventions in English metropolitan areas. Transp. Res. Interdisc. Perspect. **10**, 100371 (2021)
24. Soe, R., Sarv, L., Gasco-Hernandez, M.: Systematic mapping of long-term urban challenges. Sustainability **14**(2), 817 (2022)