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Challenges and Success Factors in Deploying Government Information Systems in the Domain of Smart Cities: The State of the Art and the State of the Practice in Brazil

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Abstract

Information systems are seen as strategic tools for managing smart cities. However, the implementation bottlenecks and essential opportunity variables are unknown. The main goal of this paper is to present the challenges and success factors mapped in the literature and the main government information systems in the field of smart cities. The methodological procedures comprises a systematic mapping study of the literature and the application of a survey research with stakeholders interested in the subject in order to evaluate the literature findings from the Brazilian perspective. At the end, 20 government information systems were identified in the literature. The results highlighted geographic expansion as the main challenge, and the main success factor was data availability. According to the participants, in the Brazilian context, the biggest challenge was public/social policies and the main success factor was governance. The potential implications highlight the advancement of research in information systems to support the management of smart cities and the assistance to researchers, public managers and information technology professionals to anticipate risks and opportunities in the implementation of information systems for smart cities.

Keywords: Challenges; Government Information Systems; Smart Cities; Success Factors.

Resumo

Os sistemas de informação são vistos como ferramentas estratégicas para a gestão de cidades inteligentes. No entanto, os desafios na implantação e variáveis essenciais de oportunidades são desconhecidos. O objetivo deste trabalho é apresentar os desafios e fatores de sucesso mapeados na literatura e os principais sistemas de informação governamentais no domínio das cidades inteligentes. Os procedimentos metodológicos envolveram um estudo de mapeamento sistemático da literatura e a aplicação de uma pesquisa com as partes interessadas no tema para avaliar os achados da literatura na perspectiva brasileira. Como resultados, foram identificados 20 sistemas de informação governamentais na literatura. Os resultados destacaram a expansão geográfica como o principal desafio e o principal fator de sucesso foi a disponibilidade de dados. De acordo com os participantes, no contexto brasileiro, o maior desafio foi políticas públicas/sociais e o principal fator de sucesso foi governança. As potenciais implicações ressaltam o avanço da pesquisa em sistemas de informação para dar suporte à gestão de cidades inteligentes e o auxílio a pesquisadores, gestores públicos e profissionais de tecnologia da informação para anteciparem riscos e oportunidades na implantação de sistemas de informação para cidades inteligentes.

Palavras-Chave: Desafios; Sistemas de Informação Governamentais; Cidades Inteligentes; Fatores de Sucesso.

1 Introduction

Cities worldwide face several challenges due to the limitations of their resources and infrastructure (Usha et al., 2020). Some digital technologies, such as intelligent sensors, telecommunications networks, Internet of things and information systems (IS), have been transforming the way people, organizations, and cities live to make them more sustainable and efficient (Rao et al., 2024).

Li et al. (2017) mention that several cities are focusing their efforts on becoming “smarter”, employing information and communication technologies (ICT) to improve several aspects of operation and management. Governments of the leading world capitals are using applications that have IS as strategic tools to establish smart cities (SC) (Důbravová and Bureš, 2023). However, there are several challenges and success factors in implementing these IS, such as developing public/social policies, IS interoperability, and user acceptance. Government IS differ from other IS, as they consider objectives and strategies focused on the social.

This work investigates the implementation of government IS to improve public management in the SC domain. To do so, the investigation was prepared according to the state of the art and practice. This way, we used methodological procedures that consisted of three steps to understand academic works and evaluate their implementation in the Brazilian context.

In the first step, an informal literature review was conducted. According to the study by Santos et al. (2008), the procedures for the development of this work aim to identify the basic concepts that underpin the definition of a precise and comprehensive protocol in the literature. Thus, the initial step involved defining the concepts of government IS applied to SC. Next, based on a systematic mapping study (SMS) (Petersen et al., 2015), the second step sought to identify the main government IS in SC and the challenges and success factors cited in implementing these IS from the state of the art.

Finally, in the third step, we conducted a survey research to understand the perceptions of Brazilian students, researchers, and professionals interested in the subject (IS and SC). This step referred to the government IS identified in the SMS and the challenges and success factors encountered from the state of the practice, as commonly performed in applied research (Prodanov and De Freitas, 2013).

The SMS results show that 20 government IS were deployed in the SC domain. In the survey research, an IS to increase traffic accuracy was pointed out as the most relevant to be implemented in an SC in the Brazilian context. Our main contribution is identifying a set of government IS deployed in the SC domain and defining a set of challenges and success factors for implementing these systems. In addition, the results of this work can help researchers and public managers choose IS for other initiatives in the SC context.

The remainder of this article is organized as follows: Section 2 presents the background; Section 3 describes the methodological procedures; Section 4 presents the steps and reports the results; and Section 5 concludes the work with some final remarks and future work.

2 Literature Review

An SC proposes solving urban problems using technology to offer better public services and quality of life for citizens (Richter et al., 2022). However, there are several definitions of SC in the literature. Partridge (2004) presents a human perspective on the digital divide in SC and defines them as cities where ICT strengthens freedom of expression, access to information, and public services. SC have dimensions of action that vary according to local needs and governance models.

According to Giffinger et al. (2007), the dimensions vary among components that involve: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. For each dimension of an SC, there are countless opportunities to use IS as a strategic tool to achieve objectives since the solutions may vary (Jayasena et al., 2019). Silva and Di Serio (2021) consider that small companies can contribute to solutions through owner-centered innovation. However, Morozov and Bria (2018) argue that solutions must be citizen-centered to achieve the ideal SC model.

2.1 Government information systems

The use of ICT to help public management has been strengthening the integration of IS with the proposal of efficiency and value creation with public resources (Boscarioli et al., 2017). According to Cordella and Iannacci (2010), a large part of the IS used by public authorities is based on the structure of the private sector, i.e., they are organized into operational, tactical, and strategic level systems. However, Grimsley and Meehan (2007) point out that government IS differ from private sector systems because they have objectives and strategies beyond traditional models.

Therefore, such systems include political and social objectives such as trust in government, social inclusion, community well-being, and sustainability. Government IS establish a set of procedures to achieve broader objectives to reduce bureaucracy and increase the efficiency of public services (Lytras and Şerban, 2020). Silva and Di Serio (2021) consider that small businesses can contribute to the maturation of solutions with a focus on innovative actions, mainly by exploring the potential of localities.

Several works commonly cite some objectives when referring to a government IS. The main objectives can be defined as (i) being centered on the citizen and improving the services offered; (ii) improving the quality of life of less favored communities and reducing social exclusion; and (iii) improving the productivity (and efficiency) of government agencies by strengthening good governance and expanding public participation (Council, 2002).

2.2 Related work

Mishra and Mishra (2012) present a literature review investigating challenges, barriers, and success factors in implementing government IS. However, the authors present results outside the SC domain. Investigating these factors in the context of SC strengthens the development

of solutions for effective city management.

Another related work conducted by [Omar et al. \(2016\)](#) presented a qualitative analysis of the challenges and barriers to implementing government IS. Their results point out that centralization of data, training and technical skills, resources for training, perception, government policies and regulations, and lack of knowledge influence government IS projects. The present work complements the study by [Omar et al. \(2016\)](#) in pointing out other challenges and success factors related to the SC context.

[Romani et al. \(2023\)](#) conducted a survey to investigate citizens' perception of security and trust in technology in SC. The authors provide a complementary vision of security and the use of information technology in SC, as it also highlights the concern of governments and entities seeking to implement solutions and applications for SC. Additionally, [de Castro and Dufloth \(2023\)](#) conducted a study using descriptive qualitative-quantitative research that analyzed the usability of 26 government systems in Brazilian capitals. The article identified the main challenges supported by Standard NBR 9241-11.

Finally, some studies deal with challenges, barriers, and success factors for SC ([Kogan and Lee, 2014](#); [Ismagilova et al., 2019](#); [Krishnan et al., 2020](#)). However, it is worth mentioning that this work differs from the others by investigating challenges and success factors in implementing government IS in the SC domain besides relating the results to the citizen's perspective through qualitative analysis.

3 Methodological Procedures

We carried out the methodological procedures used in this work in three steps, as shown in [Fig. 1](#). The first step identified government IS concepts for SC through an informal literature review ([Santos et al., 2008](#)). The second step aimed to identify the main IS that support governments in the SC context through an SMS ([Petersen et al., 2015](#)). In the third step, we conducted a survey research based on an online questionnaire to understand citizens' perceptions in the Brazilian context regarding the IS identified in the SMS, as performed in applied research ([Prodanov and De Freitas, 2013](#)). The protocols used in the SMS and in the survey research are presented next.

4 Steps and Results

4.1 The state of the art

We characterize the state of the art of government IS in the SC domain through an SMS, which consists of a method for mapping studies published in each domain. The objective of the SMS based on the analysis of SC with the purpose of identifying IS, challenges and success factors with respect to its implementation from the point of view of researchers in the context of government.

According to [Kitchenham et al. \(2009\)](#), the following phases are proposed for secondary studies: planning, conducting, and analysis of results. Secondary studies consist of drawing conclusions from primary studies, such as summary records of work that are common to the study.

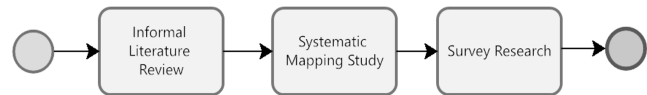


Figure 1: Methodological procedures

4.1.1 Planning

The research question (RQ) of this SMS was the following: **Which government IS and how have they been implemented in the domain of CS?** We defined research sub-questions (Sub-Q) to help answer the RQ, as shown in [Table 1](#). Our research strategy searched six digital libraries: [ACM Digital Library](#), [Engineering Village](#), [IEEE Xplore](#), [ScienceDirect](#), [Scopus](#), and [Web of Science](#). We gathered the search terms into a search string, as shown in [Table 2](#). The SMS protocol detail is openly available in a technical report available in an open repository¹.

Table 1: Research sub-questions

ID	Research sub-questions
Sub-Q1	Which government IS were implemented in the SC domain, and what are their characteristics (i.e., name, type and purpose)?
Sub-Q2	What challenges were identified in deploying government IS in the SC domain?
Sub-Q3	What success factors were identified after the deployment of government IS in the SC domain?

Table 2: Search string

Search string
("smart cities" OR "smart city") AND ("information system" OR "information systems") AND ("government" OR "public administration")

4.1.2 Conduction

After defining the SMS protocol, we retrieved 457 studies. In turn, after applying the selection and exclusion criteria, we selected 20 secondary studies for analysis. We present the selection process in [Fig. 2](#). Three researchers participated in the procedures for selecting studies.

Two researchers initially evaluated each study, and, in case of disagreement, the third researcher evaluated the study to define whether it would be included or excluded. The third and fourth researchers, more experienced in the execution of secondary studies (more than 15 years of experience), reviewed the results of the selection of studies and the other stages of the SMS. The distribution of studies over the years can be seen in [Fig. 3](#), and the list of selected studies is also available in the open repository mentioned previously. Selected studies are referred to as S1-S20.

¹<https://doi.org/10.7910/DVN/NYGFBE>

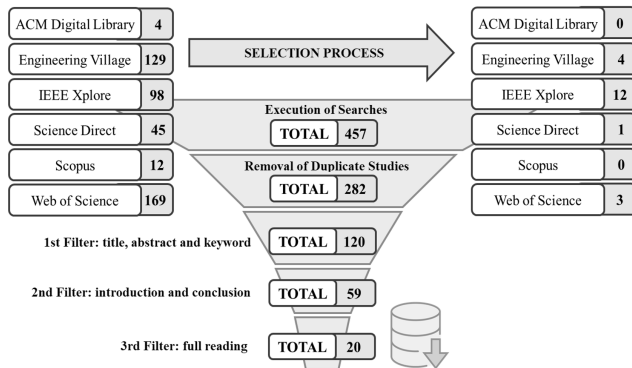


Figure 2: Study selection process

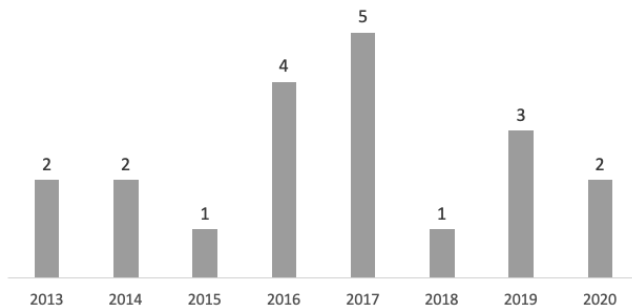


Figure 3: Number of studies per year of publication

4.1.3 Analysis of results

To allow answering the RQ of this SMS, we present the answers to each Sub-Q in the following subsections.

4.1.3.1 Sub-Q1: Which government IS were implemented in the SC domain, and what are their characteristics (i.e., name, type and purpose)? The selected studies mentioned 20 government IS implemented in the SC domain. However, the selected studies named only ten government IS. All government IS analyzed are presented in Table 3 with their respective name, type, and purpose. The non-identified data are pointed out as NI. S8 points out nine proposed solutions for SC, not being possible to identify the IS (indicated as NI in Table 3, either for name or type).

4.1.3.2 Sub-Q2: What challenges were identified in deploying government IS in the SC domain? Not all included studies made clear challenges in the implementation of IS. Fifteen selected studies reported challenges (75%). Few studies said similar situations, which leads to the understanding that the challenges are particular to each project and each reality in which it is inserted. Only two challenges were repeated in different studies: geographic expansion (S7, S19), and concern about data privacy (S4, S19). In Table 4, we present the challenges identified in the selected studies.

4.1.3.3 Sub-Q3: What success factors were identified after the deployment of government IS in the SC domain? Table 5

presents the success factors identified in the selected studies. We highlight the relevance of the data availability (with three occurrences) and the use of efficient algorithm (with two occurrences). Among the studies in which data availability was a success factor, S2 indicates that the use of geospatial data sharing in network mode contributed to the success of the government IS. S3, in turn, stresses the use of open data in any language and the storage of georeferenced data in the public domain. Finally, S10 shows how easy obtaining data from public databases is due to legislation encouraging open data use.

4.2 The state of the practice in Brazil

We characterize the state of the practice on government IS in the domain of CS in the Brazilian context. The methodological procedures used in this survey research were based on Kitchenham and Pfleeger (2008)'s guidelines. We applied the GQM method (Basili and Rombach, 1988) to define the goal: *analyzing the findings of the SMS with the aim of verifying with respect to the agreements concerning the government IS, challenges and success factors from the point of view of students, researchers, and professionals in the Brazilian context.*

Thus, our goal was to verify which government IS implemented in the SC domain selected in the SMS are considered important in the Brazilian context. Furthermore, we sought to verify whether the respondents' opinions confirmed the challenges and success factors. We conduct the study in three phases: instrumentation, execution, and analysis of results.

4.2.1 Instrumentation

We applied a questionnaire composed of three sections as a survey research instrument. Section 1 had a brief presentation of the study, Section 2 contained questions about the participants' profiles (Table 6), and Section 3 had specific questions about the research (Table 7). Sections 2 and 3 contained open questions (OQ) and closed questions (CQ). Before conducting the survey research, we performed a pilot with two participants to evaluate and refine the questionnaire. Based on the pilot notes, we adjusted the IS descriptions listed in Q6 to improve the respondents' understanding.

4.2.2 Execution

The survey research was carried out in Brazil and the questionnaire was written in Portuguese, which was sent out to students, researchers, and professionals interested in IS and SC through various electronic communication channels such as emails, groups of teachers and students on WhatsApp, and professionals registered on the social network platform LinkedIn.

It was not possible to obtain the total number of invitations sent due to the use of communication channels that allowed for broad sharing of information. In addition, we did not consider the respondents' experience with the topic, as the intention was to receive as many responses as possible within the period defined in the planning.

We received 38 responses with the signed consent form, which allowed us to carry out the quantitative

Table 3: List of government IS used in the SC domain (NI = non-identified data)

ID	IS name	IS goal	Year	Study source
S1	Abuja Geographic Information System (AGIS)	Prevent slum growth through housing allocation	2013	Faniran and Olaniyan (2013)
S2	NI	Analyze social networks to plan urban actions and improve decision-making	2013	Tao (2013)
S3	NI	Assist in urban emergencies and disasters	2014	Consoli et al. (2014)
S4	NI	Assist in public safety	2014	Cilliers and Flowerday (2014)
S5	NI	Assist in parking management	2015	Zheng et al. (2015)
S6	Monvis-Musrenbang	Monitor service requests using gamification platform	2016	Rakhmawati and Fibrianto (2016)
S7	ParticipAct	Assist people with reduced mobility	2016	Cortellazzi et al. (2016)
S8	NI	Collect and process urban sensor data	2016	Yau et al. (2016)
S9	ArcGIS Network Analyst	Route collection of residential recyclables	2016	Küs et al. (2016)
S10	NI	Identify region with the highest electricity consumption	2017	Carpentieri and Favo (2017)
S11	National Geographic Information System (NGIS)	Provide information on weather, rainfall and water level	2017	Chou and Hsu (2017)
S12	RSmart Geo Layers	Gather and unify open government data and visualize by georeferencing	2017	Souza et al. (2017)
S13	City113	Provide citizens with a channel for denouncing government issues	2017	Susanto et al. (2017)
S14	NI	Mitigate natural disasters	2017	Hartama et al. (2017)
S15	NI	Increase traffic accuracy, shorten transit time, and locate traffic accidents	2018	Tai et al. (2018)
S16	SiWarga Patehan	Streamline administrative services and measure service quality	2019	Rachmawati et al. (2019)
S17	NI	Monitor borders	2019	Svitek et al. (2019)
S18	Tangerang Live	Manage user complaints	2019	Nindito et al. (2019)
S19	Taichung Bus Data	Monitor public transport	2020	Wang et al. (2020)
S20	NI	Provide citizens with better public transport services	2020	Kurniawan et al. (2020)

and qualitative analysis of the results. Kitchenham et al. (2015) highlight that a minimum of at least 30 responses is desirable if the objective is to carry out any form of statistical analysis in survey research. Still, as described by Ahmed (2023), the number of participants may face limitations, such as limited data availability, potential biases in surveys and interviews, as well as the generalization of the findings.

These limitations are acknowledged and addressed in the discussion. Finally, it is worth highlighting that the results of the survey research provide a preliminary assessment of the results obtained in the SMS. The survey research data are openly available in an open repository².

4.2.3 Analysis of results

We perform quantitative and qualitative data analysis. For quantitative analysis, we used descriptive statistics to summarize and describe the data obtained in the CQ and for qualitative analysis, a structure was developed to understand the challenges and success factors in the implementation of IS in the SC, as perceived by the interviewees. Qualitative analysis is used to understand, describe and explain social phenomena differently (Baskerville and Myers, 2015). Some qualitative analysis methods use coding procedures, such as content analysis, thematic analysis and Grounded Theory (GT). In this

work, we applied coding procedures to analyze data inspired by Strauss and Corbin (2008) methods of GT, which is based on 3 types of coding: (i) open coding; (ii) axial coding; and (iii) selective coding.

In open coding, the data is categorized based on reading the answers, separating their excerpts, and assigning them to a word, phrase, or expression category. The axial coding aims to identify the relationships among the categories of the previous coding after improving and differentiating these categories. In selective coding, the category or central idea of the study is identified.

Our qualitative analysis was based on the data obtained from Q10 (“Mention challenges to be overcome for implementing information systems for smart cities”) and Q11 (“Mention success factors for implementing information systems for smart cities”). We aimed to understand the challenges and success factors participants pointed out based on the coding procedures. Despite the GT citing three types of coding, according to Strauss and Corbin (2008), it is up to the researcher to define which ones will be used to satisfy the research needs.

In this work, which only aimed to conduct a qualitative analysis of the survey research results, we performed only the first two encodings (open and axial). To define the codes in the open coding phase, two researchers read all the participants’ responses and analyzed each one so that it was possible to associate excerpts from the responses to the codes. After this step, the codes were grouped into categories that represent a higher level of abstraction. The

²<https://doi.org/10.7910/DVN/DVNFMR>

Table 4: Challenges in IS implementation

ID	Challenge	Study source
S4, S19	Concern about data privacy	Cilliers and Flowerday (2014), Wang et al. (2020)
S7, S19	Geographic expansion	Cortellazzi et al. (2016), Wang et al. (2020)
S13	Acceptance of citizens	Susanto et al. (2017)
S10	Data divergence between systems	Carpentieri and Favio (2017)
S19	Deployment cost	Wang et al. (2020)
S17	Functionality expansion	Svitek et al. (2019)
S12	Implementing smart layers	Souza et al. (2017)
S20	Incomplete and inaccurate data	Kurniawan et al. (2020)
S20	Lack of disclosure	Kurniawan et al. (2020)
S1	Lack of government or population data	Faniran and Olaniyan (2013)
S9	Limitation of the technology used	Kûs et al. (2016)
S3	Need for integration between systems	Consoli et al. (2014)
S5	Parking availability forecasts	Zheng et al. (2015)
S2	Possibility of increasing urban population	Tao (2013)
S3	Unexpected obstacles	Consoli et al. (2014)

other two more experienced researchers reviewed the code selection and grouping analysis.

4.2.4 Quantitative results

We determined the respondents' demographics according to the responses in section 2 of the questionnaire (Table 6). These data helped to understand the respondent's profiles. From 38 participants in the survey research, 47.4% identified themselves as male, and 52.6% identified as female. The distribution of participants by age group shows the most significant portion (63.2%) of participants aged between 18 and 30. Regarding the area of activity, 50% of the participants work in academia as a student and/or professor, 21.1% work in the private sector, 15.8% in the public sector, 5.3% in the third sector, 5.3% as self-employed, and 2.6% did not fit the response options. Regarding the region where respondents live, 50% live in the North Region, 42.1% in the Southeast Region, and 7.9% in the Midwest Region.

About specific questions, Q5 first sought to identify whether respondents were aware of any technological solution offered by the government. Most respondents (52.6%) stated that they knew of a solution. Moreover, for Q5, respondents had to report how they use the solutions offered by the government. Among 38 respondents, 24 answered this question, and the vast majority (95.8%) responded that they use smartphones to access the solutions. Other options were personal computers (system) with 33.3% and call centers with 8.3%.

In Q6, the respondents had to indicate the level of agreement regarding the government IS implemented in the SC domain, i.e., to which extent each system listed, arising from the SMS results (Table 3), is important to

Table 5: Success factors in the implementation of IS

ID	Success factor	Study source
S2, S3, S10	Data availability	Tao (2013), Consoli et al. (2014), Carpentieri and Favio (2017)
S5, S9	Use of efficient algorithm	Zheng et al. (2015), Kûs et al. (2016)
S7	Application programming interface availability	Cortellazzi et al. (2016)
S3	Creation of recommended services ontology	Consoli et al. (2014)
S13	Ease of use	Susanto et al. (2017)
S16	Process improvements	Rachmawati et al. (2019)
S15	Technology available and easily accessible	Tai et al. (2018)
S2	Use of sensors	Tao (2013)

Table 6: Demographic questions of the questionnaire

ID	Question
Q1	What gender do you identify with?
Q2	What is your age group?
Q3	In which area do you work?
Q4	What region do you live in?

make a city smarter. IS15 had the highest percentage of "I totally agree" responses, with 89.5%, even though the name of the IS was not presented in the study. Thus, respondents would understand this system as the most important for an SC. IS17, in turn, was the system with the lowest number of "I totally agree" responses, with 44.7%. We emphasize that the number of "totally disagree" and "partially disagree" responses were very low for each. These scores demonstrate that respondents understand that, in general, the implementation of the listed IS is of relative importance in the domain.

In Q7, respondents should indicate who would most appropriately deploy such IS between government and/or technology companies. The majority (52.6%) said that the most appropriate thing would be for both to be involved in implementing IS for SC. In Q8, respondents had to give their opinion on the main challenges for IS implementation. The aspect indicated as the most significant challenge by the respondents was the cost of implementation, pointed out by 62.2%. The least challenging aspect was citizens' acceptance, pointed out by 26.3% of respondents.

Q9 dealt with the success factors of IS implementation. The respondent should indicate the most important and least important factors. We observed that ease of use was the most important in 83.8% of respondents (value 5). Other factors that respondents considered important were available and easily accessible technology, 76.3% of responses, and process improvements, 64.9% of responses. On the other hand, the availability of application programming interface and the use of sensors had a high number of answers on value 3, 26.3% and 25%, respectively. There were only four responses on value 2, and no respondent rated any factor on value 1.

Table 7: Specific questions of the questionnaire

ID	Question
Q5	Are you aware of any technological solution offered by the government? If yes, what would be the solution? And how do you use it?
Q6	In a scale of totally agree, partially agree, neither agree nor disagree, partially disagree and totally disagree, do you consider the listed systems as important for making a smart city?
Q7	Considering the choice of the most important system, in your opinion, who should offer this solution?
Q8	In a scale where 5 is greater difficulty and 1 is lesser difficulty, rank the challenges for implementing information systems.
Q9	In a scale where 5 is the most important and 1 is the least important, what success factors do you consider the most important for creating smart cities?
Q10	Mention challenges to be overcome for implementing information systems for smart cities.
Q11	Mention success factors for implementing information systems for smart cities.

4.2.5 Qualitative results

For the qualitative analysis, we used Atlas.TI³ as software for organizing and carrying out the qualitative codification of the data. As such, we identified two categories with which the codes could be related in the studies. Based on the objectives of Q10 and Q11, we defined these categories as challenges and success factors for implementing IS in SC. In Table 8, we present the codes related to the categories and the number of citations of each. The code Others cited in both categories was used to group challenges (5) and success factors (3) when it was not possible to do any classification.

Table 8: Open coding codes

Code	Category	Mentions
Public/Social Policy	Challenges	11
Interoperability	Challenges	5
Others	Challenges	5
Acceptance	Challenges	4
Data privacy	Challenges	4
Cost	Challenges	3
Infrastructure	Challenges	3
Efficiency	Challenges	2
Collaboration	Challenges	1
Governance	Success Factors	11
Efficiency	Success Factors	8
Collaboration	Success Factors	5
Technologies	Success Factors	5
Others	Success Factors	3
Environment	Success Factors	2
Mobility	Success Factors	2
Information Security	Success Factors	1
Investment	Success Factors	1

Regarding the Challenges category, the code that

obtained the highest number of citations was Public/Social Policy, which is directly related to the engagement between society and governments, mainly on awareness, as highlighted by Respondent 25. The Interoperability code, the second most cited one, also demonstrates the lack of integration between the IS. This challenge requires a broad relationship among stakeholders to make cities smarter, as highlighted in the Grand Research Challenges in IS in Brazil 2016–2026 (Boscarioli et al., 2017) and can be understood by Respondent 17's comment:

"I believe that the biggest challenge today is the political and social issue that our country is facing. It is very important in implementing smart cities that the government participates directly, encouraging and collaborating." [Respondent 25]

"Interoperability among systems, conflicting information among systems." [Respondent 17]

Still in the Challenges category, respondents also cited Acceptance and Data Privacy. In the respondents' opinion, concerning Acceptance, the IS must first be accepted by society to serve all types of people, as highlighted by Respondents 4 and 38. Regarding Data Privacy, privacy may be compromised to the extent that many people use the IS. Respondent 36 quotes this code:

"Population acceptance of the benefits that could bring to the process of improvements in the production and the population's history process about this." [Respondent 4]

"Acceptance of the population and people who support the projects." [Respondent 38]

"One of the main challenges of any IS is to maintain the privacy of its users effectively." [Respondent 36]

With respect to the Success Factors category, Governance was the most cited by respondents. Respondents highlighted the following points: more security, transparency, and participation by society. The citation of this code reinforces that providing services related to public administration is the main success factor respondents consider. They cited Efficiency as the second top code as it is significant for implementing IS to manage public resources. The quotes below present some points highlighted by the respondents:

"Partnership between public and private sectors, strategic planning and investments to optimize services." [Respondent 15]

"Bureaucratic agility, optimization of people's time, economy etc." [Respondent 24]

In addition, in the Success Factors category, Collaboration is directly linked to the benefits that engagement between stakeholders and society can provide. In this code, it is also possible to understand the success factors generated by public and private power partnerships, as highlighted by Respondents 6 and 30. In turn, Technologies seeks to represent the benefits related

³<https://atlasti.com/>

to the development of new systems using services by society, as Respondent 10 highlights:

“Integration between public and private sectors, partnerships among institutions, trained professionals with experience...” [Respondent 6]

“Public engagement, transparency for independent audits, mechanisms for planning evolution, concern for the city’s sustainability and processes, monitoring of goals before the citizens etc.” [Respondent 30]

“New technologies emerge all the time, facilitating software and hardware development.” [Respondent 10]

4.3 Discussion

The analysis of the state of the art enabled the identification of 20 government IS implemented in the SC domain and the identification of challenges and success factors related to this implementation. The most relevant challenges highlighted in the selected studies include concerns about data privacy and geographic expansion. Regarding data privacy, data protection strategies may not be directly applied to SC applications due to heterogeneity, scalability, and dynamic characteristics (Cui et al., 2018).

Regarding geographic expansion, this challenge was recognized as an urban problem associated with environmental degradation, motivated by urban expansion, and mainly due to the lack of public policies on the intelligent management of cities (Kim et al., 2021). The main Success Factor identified in the SMS refers to Data Availability. Filgueiras and Silva (2022) clarify that this factor is related to data governance, which is the decision-making process and the construction of authority to specify decision rights and responsibility, using security and data integrity. Therefore, data availability is one of the main inputs for data governance, which is fundamental to the success of a SC.

The analysis of the state of the practice served to verify these results from the perspective of Brazilian students, researchers, and professionals. When triangulating the results, we observed concerns about population growth in the studies selected in the SMS and the responses we obtained in the survey research. These data reinforce the projections of the United Nations, as there is an expectation that the world will exceed the mark of 9 billion inhabitants by 2050 (Dorling, 2021).

In the qualitative results, we considered two categories to group the defined codes according to the answers obtained in the survey research. In the Challenges category, the code Public/Social Policy code received 11 citations, reinforcing the respondents’ concern with government IS aimed at meeting citizens’ real needs. The participation of society is an important aspect of city governance. Liu et al. (2022) evaluate the challenges of entrepreneurs to develop projects with the participation of society. They point out that they often rely on their own strength to obtain and invest limited resources at various stages. The proposal observed in the study demonstrates that government bodies can help the governance of

cities by offering important information from society for the development of entrepreneurial strategies. This participation, seen as social, is an essential element for the design of an SC.

In the Success Factors category, which concentrated responses more related to organizational aspects, the Governance code got 11 citations. For Bovaird and Loeffler (2015), governance can offer good public management practices as it seeks to improve processes for service efficiency. Gil-García and Pardo (2005) and Scholl and Scholl (2014) mention that intelligent governance is the main element of an SC. Nesti and Graziano (2020) state that a city can be smart if it adopts an innovative style of collaborative governance to design urban policies to improve citizens’ quality of life and promote environmental, economic, and social sustainability.

This work presented some threats to validity and limitations. According to Ampatzoglou et al. (2019), threats to conducting an SMS can be classified as study selection validity, data validity, and research validity. Threats to the study selection validity include (i) a limited selection of search sources; (ii) ineffective search strings; and (iii) bias in the selection of studies included in the SMS. To mitigate (i), we searched six digital libraries, including Scopus, which indexes work from several digital libraries; for (ii), we used control studies to ensure the effectiveness of the search string; and for (iii), this research involved four researchers. Furthermore, inclusion and exclusion criteria were applied independently by two researchers in each filter. We complemented it with the analysis of a third researcher in the following filter.

Data validity relates to (i) unverified data extraction; and (ii) author bias. To mitigate threat (i), we document all data transformations to enable us to trace them from the synthesis to the corresponding included study. Regarding (ii), two researchers performed the data extraction, and the other two validated the process and results. Finally, research validity refers to (i) lack of documentation on study planning and (ii) lack of justification for changes during the conduct of the study. To mitigate (i) and (ii), we defined a detailed protocol based on well-established SMS guidelines and made it available online.

Regarding the survey research, a limitation is the number of participants. Smith et al. (2013) state that attracting many participants to online surveys is still challenging. Moreover, we emphasize that the context of SC research is recent and, in this study, a little-explored aspect was also included: citizen participation. Finally, most OQ responses were short and objective, which may have hampered the qualitative analysis. However, we have aimed for the maximum utilization of the responses in our codifications.

5 Conclusion

This work aimed to identify government IS deployed in the SC domain. Moreover, we analyzed challenges and success factors related to implementing these systems. To achieve this goal, we conducted an SMS and a survey research. From 457 retrieved studies, we selected 20 studies in our SMS. The main challenges identified in the SMS

involve geographic expansion and data privacy concerns. Concerning success factors for the implementation of IS in SC, data availability had the highest number of citations. In the survey research, the most relevant IS for respondents was increased traffic accuracy (IS15). The most cited challenge by respondents for implementing these systems was related to public/social policies. Several respondents mentioned governance as a success factor, which can be considered a research opportunity.

In this sense, the results reinforce that the advancement of SC cannot be understood solely from a technological perspective, since the institutional, regulatory, and social dimensions demonstrate a decisive role in the implementation processes. Thus, this study contributes to the consolidation of research on government IS in the domain of SC, providing an integrated perspective that connects technology, governance, and public policies. Furthermore, the study organizes dispersed evidence into an analytical structure that can support future research and practical initiatives.

The identification of governance and data availability as structuring elements suggests timely directions for the evolution of data-driven public management models. Investigating the interoperability of IS and open data strategies can contribute to studies on the development of implementation guidelines in SC. As future work, we intend to deepen the investigation into how the implementation of government IS can contribute to the development of SC, as well as conduct comparative analyses and adopt impact assessment models that support guidelines for technological innovation, urban sustainability, and social transformation.

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References

- Ahmed, S. (2023). Challenges of climate change in nature tourism in bangladesh: Evidence from hill tracks, *Revista Gestão & Tecnologia* 23(3): 361–376. Available at <https://doi.org/10.20397/2177-6652/2023.v23i3.2734>.
- Ampatzoglou, A., Bibi, S., Avgeriou, P., Verbeek, M. and Chatzigeorgiou, A. (2019). Identifying, categorizing and mitigating threats to validity in software engineering secondary studies, *Information and Software Technology* 106: 201–230. Available at <https://doi.org/10.1016/j.infsof.2018.10.006>.
- Basili, V. R. and Rombach, H. D. (1988). The tame project: Towards improvement-oriented software environments, *IEEE Transactions on software engineering* 14(6): 758–773. Available at <https://doi.org/10.1109/32.6156>.
- Baskerville, R. L. and Myers, M. D. (2015). Design ethnography in information systems, *Information Systems Journal* 25(1): 23–46. Available at <https://doi.org/10.1111/isj.12055>.
- Boscarioli, C., de Araujo, R. M., Maciel, R. S., Neto, V. V. G., Oquendo, F., Nakagawa, E. Y., Bernardini, F. C., Viterbo, J., Vianna, D., Martins, C. B. et al. (2017). I grandsi-br: Grand research challenges in information systems in brazil 2016-2026.
- Bovaird, T. and Loeffler, E. (2015). Public management and governance: The future?, *Public Management and Governance*, Routledge, pp. 395–409. Available at <https://doi.org/10.4324/9781003282839-33>.
- Carpentieri, G. and Favio, F. (2017). The end-use electric energy consumption in urban areas: A gis-based methodology. an application in the city of naples., *TeMA-Journal of Land Use, Mobility and Environment* 10(2): 139–156. Available at <https://doi.org/10.6092/1970-9870/5173>.
- Chou, T.-Y. and Hsu, Y.-T. (2017). The strategic development and spatial information applications of smart cities in taiwan, *2017 Pacific Neighborhood Consortium Annual Conference and Joint Meetings (PNC)*, Ieee, pp. 1–7.
- Cilliers, L. and Flowerday, S. (2014). Information security in a public safety, participatory crowdsourcing smart city project, *World Congress on Internet Security (WorldCIS-2014)*, IEEE, pp. 36–41. Available at <https://doi.org/10.1109/WorldCIS.2014.7028163>.
- Consoli, S., Gangemi, A., Nuzzolese, A. G., Peroni, S., Presutti, V., Recupero, D. R., Spampinato, D. et al. (2014). Towards emergency vehicle routing using geolinked open data: the case study of the municipality of catania., *SSA-SMILE@ESWC*, pp. 31–42. Available at https://doi.org/10.1007/978-3-319-11955-7_4.
- Cordella, A. and Iannacci, F. (2010). Information systems in the public sector: The e-government enactment framework, *The Journal of Strategic Information Systems* 19(1): 52–66. Available at <https://doi.org/10.1016/j.jsis.2010.01.001>.
- Cortellazzi, J., Foschini, L., De Rolt, C. R., Corradi, A., Neto, C. A. A. and Alperstedt, G. D. (2016). Crowdsensing and proximity services for impaired mobility, *2016 IEEE Symposium on Computers and Communication (ISCC)*, IEEE, pp. 44–49. Available at <https://doi.org/10.1109/ISCC.2016.7543712>.
- Council, P. (2002). Roadmap for e-government in the developing world: 10 questions e-government leaders should ask themselves, *Pacific Council on International Policy*.
- Cui, L., Xie, G., Qu, Y., Gao, L. and Yang, Y. (2018). Security and privacy in smart cities: Challenges and opportunities, *IEEE access* 6: 46134–46145. Available at <https://doi.org/10.1109/ACCESS.2018.2853985>.

- de Castro, M. A. A. and Dufloth, S. C. (2023). Usabilidade no acesso mobile a serviços e informações de portais governamentais: a realidade das capitais brasileiras, *Revista Gestão & Tecnologia* 23(2): 129–159. Available at <https://doi.org/10.20397/2177-6652/2023.v23i2.2281>.
- Dorling, D. (2021). World population prospects at the un: our numbers are not our problem?, *The struggle for social sustainability*, Policy Press, pp. 129–154. Available at <https://doi.org/10.46692/9781447356127.008>.
- Důbravová, H. and Bureš, V. (2023). Smart city information systems: Research on information published for citizens and design of effective content in the czech republic, *Smart Cities* 6(5): 2960–2981. Available at <https://doi.org/10.3390/smartsities6050133>,.
- Faniran, S. and Olaniyan, K. (2013). From slums to smart cities: addressing slum-dwelling in nigeria through e-land administration, *Proceedings of the 7th International Conference on Theory and Practice of Electronic Governance*, pp. 186–189. Available at <https://doi.org/10.1145/2591888.2591919>.
- Filgueiras, F. and Silva, B. (2022). Designing data policy and governance for smart cities: theoretical essay using the iad framework to analyze data-driven policy, *Revista de Administração Pública* 56(4): 508–528. Available at <https://doi.org/10.1590/0034-761220220078x>.
- Giffinger, R., Fertner, C., Kramar, H., Meijers, E. et al. (2007). City-ranking of european medium-sized cities, *Cent. Reg. Sci. Vienna UT* 9(1): 1–12.
- Gil-García, J. R. and Pardo, T. A. (2005). E-government success factors: Mapping practical tools to theoretical foundations, *Government information quarterly* 22(2): 187–216. Available at <https://doi.org/10.1016/j.giq.2005.02.001>.
- Grimsley, M. and Meehan, A. (2007). e-government information systems: Evaluation-led design for public value and client trust, *European Journal of Information Systems* 16(2): 134–148. Available at <https://doi.org/10.1057/palgrave.ejis.3000674>.
- Hartama, D., Mawengkang, H., Zarlis, M., Sembiring, R. W., Nasution, B. B., Syahrudin, M., Nastia, P., Sembiring, A. L., Saifullah, Irawan, E. et al. (2017). The planning of smart city to mitigate the impacts of natural disaster in north sumatera, *International Conference on Information Technology in Disaster Risk Reduction*, Springer, pp. 147–154. Available at https://doi.org/10.1007/978-3-319-68486-4_12.
- Ismagilova, E., Hughes, L., Dwivedi, Y. K. and Raman, K. R. (2019). Smart cities: Advances in research—an information systems perspective, *International journal of information management* 47: 88–100. Available at <https://doi.org/10.1016/j.ijinfomgt.2019.01.004>.
- Jayasena, N., Mallawaarachchi, H. and Waidyasekara, K. (2019). Stakeholder analysis for smart city development project: an extensive literature review, *MATEC web of conferences*, Vol. 266, EDP Sciences, p. 06012. Available at <https://doi.org/10.1051/mateconf/201926606012>.
- Kim, H. M., Sabri, S. and Kent, A. (2021). Smart cities as a platform for technological and social innovation in productivity, sustainability, and livability: A conceptual framework, *Smart cities for technological and social innovation*, Elsevier, pp. 9–28. Available at <https://doi.org/10.1016/B978-0-12-818886-6.00002-2>.
- Kitchenham, B. A., Budgen, D. and Brereton, P. (2015). *Evidence-based software engineering and systematic reviews*, Vol. 4, CRC press. Available at <https://doi.org/10.1201/b19467>.
- Kitchenham, B. A. and Pfleeger, S. L. (2008). Personal opinion surveys, *Guide to advanced empirical software engineering*, Springer, pp. 63–92. Available at https://doi.org/10.1007/978-1-84800-044-5_3.
- Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J. and Linkman, S. (2009). Systematic literature reviews in software engineering—a systematic literature review, *Information and software technology* 51(1): 7–15. Available at <https://doi.org/10.1016/j.infsof.2008.09.009>.
- Kogan, N. and Lee, K. J. (2014). Exploratory research on the success factors and challenges of smart city projects, *Asia Pacific Journal of Information Systems* 24(2): 141–189. Available at <https://doi.org/10.14329/apjis.2014.24.2.141>.
- Krishnan, B., Arumugam, S. and Maddulety, K. (2020). Critical success factors for the digitalization of smart cities, *International Journal of technology management & sustainable development* 19(1): 69–86. Available at https://doi.org/10.1386/tmsd_00016_1.
- Kurniawan, Y., Bhutkar, G., Berlian, A. R. K., Tando, G. S. C., Fahira, D., Daventa, S., Angeline, E. et al. (2020). Does the existence of connected transport mobile application affect transjakarta passengers?, *2020 International Conference on Information Management and Technology (ICIMTech)*, IEEE, pp. 464–469. Available at <https://doi.org/10.1109/ICIMTech50083.2020.9211245>.
- Kůs, K., Cheu, R. L. and Horak, T. (2016). Gis approach in vehicle route optimization for residential recyclables collection, *2016 Smart Cities Symposium Prague (SCSP)*, IEEE, pp. 1–6. Available at <https://doi.org/10.1109/SCSP.2016.7501024>.
- Li, X.-X., Zhu, Y.-W. and Wang, J. (2017). Efficient encrypted data comparison through a hybrid method, *Journal of Information Science & Engineering* 33(4). Available at <https://doi.org/10.6688/JISE.2017.33.4.6>.
- Liu, Y. L., Peng, X. B. and Huang, J. (2022). The impact of entrepreneurs' social identity and the mediation effect of the decision-making logic on the bootstrapping behavior of nascent ventures, *Revista Brasileira de Gestão de Negócios* 24: 617–637. Available at <https://doi.org/10.7819/rbgn.v24i4.4208>.
- Lytras, M. D. and Şerban, A. C. (2020). E-government insights to smart cities research: European union (eu)

- study and the role of regulations, *IEEE Access* 8: 65313–65326. Available at <https://doi.org/10.1109/ACCESS.2020.2982737>.
- Mishra, A. and Mishra, D. (2012). E-government: exploring the different dimensions of challenges, implementation, and success factors, *ACM SIGMIS Database: the DATABASE for Advances in Information Systems* 42(4): 23–37. Available at <https://doi.org/10.1145/2096140.2096143>.
- Morozov, E. and Bria, F. (2018). Rethinking the smart city, *Democratizing urban technology* 2. Available at <https://doi.org/10.6092/ISSN.2612-0496/8864>.
- Nesti, G. and Graziano, P. R. (2020). The democratic anchorage of governance networks in smart cities: an empirical assessment, *Public Management Review* 22(5): 648–667. Available at <https://doi.org/10.1080/14719037.2019.1588355>.
- Nindito, H., Madyatmadja, E. D. and Sano, A. V. D. (2019). Evaluation of e-government services based on social media using structural equation modeling, *2019 International Conference on Information Management and Technology (ICIMTech)*, Vol. 1, IEEE, pp. 78–81. Available at <https://doi.org/10.1109/ICIMTech.2019.8843723>.
- Omar, A., Bass, J. M. and Lowit, P. (2016). Exploring the factors that influence the success of insourced government ict projects, *The Electronic Journal of Information Systems in Developing Countries* 77(1): 1–21. Available at <https://doi.org/10.1002/j.1681-4835.2016.tb00564.x>.
- Partridge, H. L. (2004). Developing a human perspective to the digital divide in the 'smart city', *Australian library and information association biennial conference*.
- Petersen, K., Vakkalanka, S. and Kuzniarz, L. (2015). Guidelines for conducting systematic mapping studies in software engineering: An update, *Information and software technology* 64: 1–18. Available at <https://doi.org/10.1016/j.infsof.2015.03.007>.
- Prodanov, C. C. and De Freitas, E. C. (2013). *Metodologia do trabalho científico: métodos e técnicas da pesquisa e do trabalho acadêmico-2ª Edição*, Editora Feevale.
- Rachmawati, R. et al. (2019). Utilization & quality of information system for administration services based on ict in patehan, kraton, yogyakarta, *Indonesian Journal of Science and Technology* 4(1): 55–63. Available at <https://doi.org/10.17509/ijost.v4i1.12680>.
- Rakhmawati, N. A. and Fibrianto, B. (2016). Designing a gamification for monitoring surabaya city development, *2016 International Conference on Information & Communication Technology and Systems (ICTS)*, IEEE, pp. 262–265. Available at <https://doi.org/10.1109/ICTS.2016.7910309>.
- Rao, C. K., Sahoo, S. K. and Yanine, F. F. (2024). An iot-based intelligent smart energy monitoring system for solar pv power generation, *Energy Harvesting and Systems* 11(1): 20230015. Available at <https://doi.org/10.1515/ehs-2023-0015>.
- Richter, M. A., Hagenmaier, M., Bandte, O., Parida, V. and Wincent, J. (2022). Smart cities, urban mobility and autonomous vehicles: How different cities needs different sustainable investment strategies, *Technological Forecasting and Social Change* 184: 121857. Available at <https://doi.org/10.1016/j.techfore.2022.121857>.
- Romani, G. F., Pinochet, L. H. C., Pardim, V. I. and Souza, C. A. d. (2023). A segurança como fator-chave para a cidade inteligente, a confiança dos cidadãos eo uso de tecnologias, *Revista de Administração Pública* 57(2): e2022–0145. Available at <https://doi.org/10.1590/0034-761220220145>.
- Santos, R. P., dos Santos, P. S. M., Werner, C. M. L. and Travassos, G. H. (2008). Utilizando experimentação para apoiar a pesquisa em educação em engenharia de software no brasil, *Fórum de Educação em Engenharia de Software* p. 55. Available at <https://doi.org/10.13140/2.1.2946.4002>.
- Scholl, H. J. and Scholl, M. C. (2014). Smart governance: A roadmap for research and practice, *IConference 2014 proceedings*. Available at <https://doi.org/10.9776/14060>.
- Silva, G. and Di Serio, L. C. (2021). Inovação em pequenas empresas: Rumo a uma abordagem de inovação centrada no proprietário, *Revista Brasileira de Gestão de Negócios* 23: 519–535.
- Smith, E., Loftin, R., Murphy-Hill, E., Bird, C. and Zimmermann, T. (2013). Improving developer participation rates in surveys, *2013 6th International workshop on cooperative and human aspects of software engineering (CHASE)*, IEEE, pp. 89–92. Available at <https://doi.org/10.1109/CHASE.2013.6614738>.
- Souza, A., Pereira, J., Oliveira, J., Trindade, C., Cavalcante, E., Cacho, N., Batista, T. and Lopes, F. (2017). A data integration approach for smart cities: The case of natal, *2017 International Smart Cities Conference (ISC2)*, IEEE, pp. 1–6. Available at <https://doi.org/10.1109/ISC2.2017.8090820>.
- Strauss, A. and Corbin, J. (2008). Basics of qualitative research: Techniques and procedures for developing grounded theory, 3rd ed. Available at <https://doi.org/10.4135/9781452230153>.
- Susanto, T. D., Diani, M. M. and Hafidz, I. (2017). User acceptance of e-government citizen report system (a case study of city113 app), *Procedia Computer Science* 124: 560–568. Available at <https://doi.org/10.1016/j.procs.2017.12.190>.
- Svitek, M., Horak, T., Cheu, R. L. and Ferregut, C. (2019). Smart border as a part of smart and resilient el paso, *2019 Smart City Symposium Prague (SCSP)*, IEEE, pp. 1–6. Available at <https://doi.org/10.1109/SCSP.2019.8805689>.
- Tai, W.-K., Wang, H.-C., Chiang, C.-Y., Chien, C.-Y., Lai, K. and Huang, T.-C. (2018). Rtais: road traffic accident information system, *2018 IEEE 20th*

- International Conference on High Performance Computing and Communications; IEEE 16th International Conference on Smart City; IEEE 4th International Conference on Data Science and Systems (HPCC/SmartCity/DSS)*, IEEE, pp. 1393–1397. Available at <https://doi.org/10.1109/HPCC/SmartCity/DSS.2018.00230>.
- Tao, W. (2013). Interdisciplinary urban gis for smart cities: advancements and opportunities, *Geo-spatial Information Science* 16(1): 25–34. Available at <https://doi.org/10.1080/10095020.2013.774108>.
- Usha, B. A., Sangeetha, K. N., Suchit, T. E., Shyam, A. and Suryanarayanan, A. (2020). Comprehensive review of smart cities using iot, *2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, pp. 367–371. Available at <https://doi.org/10.1109/ICRITO48877.2020.9197792>.
- Wang, J.-D., Pan, S.-H., Ho, C.-Y., Lien, Y.-N., Liao, S.-c. and Nurmandi, A. (2020). Online web query system for various frequency distributions of bus passengers in taichung city of taiwan, *IET Smart Cities* 2(3): 135–145. Available at <https://doi.org/10.1049/iet-smc.2020.0017>.
- Yau, K.-L. A., Lau, S. L., Chua, H. N., Ling, M. H., Iranmanesh, V. and Kwan, S. C. C. (2016). Greater kuala lumpur as a smart city: A case study on technology opportunities, *2016 8th International Conference on Knowledge and Smart Technology (KST)*, IEEE, pp. 96–101. Available at <https://doi.org/10.1109/KST.2016.7440496>.
- Zheng, Y., Rajasegarar, S. and Leckie, C. (2015). Parking availability prediction for sensor-enabled car parks in smart cities, *2015 IEEE tenth international conference on intelligent sensors, sensor networks and information processing (ISSNIP)*, IEEE, pp. 1–6. Available at <https://doi.org/10.1109/ISSNIP.2015.7106902>.