An Internet of Things and Smart Cities Frameworks Implementation in Municipalities: A Systematic Literature Review

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Abstract. Recent years have seen an exponential growth in Internet of Things (IoT) frameworks and smart city frameworks. In many countries, local governments are seeking smart solutions, particularly in these frameworks where IoT innovation, development, and implementation profoundly influence the environment, economy, people, living, governance, and mobility. Internet of Things (IoT) frameworks and smart city implementation in municipalities are comprehensively reviewed and analyzed in this paper. This review is designed to identify, describe, and synthesize research findings on IoT and smart cities frameworks deployments in various municipalities. Databases such as Google Scholar and Web of science were utilized to acquire articles relevant to this study's objectives by scanning their titles, abstracts, introductions, and conclusions. To obtain related data, skimming and reading full texts were used to conduct a comprehensive literature review. For a more comprehensive understanding of current research and practice, 39 relevant studies were systematically reviewed. A variety of IoT technologies, communication protocols, and machine learning applications are discussed in this study. In addition to exploring smart city implementation frameworks adopted globally, the study sheds light on a variety of key areas of interest, including mobility, governance, economy, people, living, and the environment. The findings indicate that digital technologies play an increasingly important role in both providing insights into the evolving IoT and smart city landscape within municipalities globally as well as influencing and improving the quality of life for citizens.

Keywords: Frameworks · Internet of Things · Machine Learning · Smart Cities · Systematic Literature Review

1 Introduction

In the era of rapid development and technological advancement, the concept of smart cities has emerged as a transformative approach to address the complex challenges posed by urban living (Ezugwu et al. 2021). Smart cities leverage digital technologies, data analytics, and innovative frameworks to create efficient, sustainable, and livable urban environments (Lai, et al. 2020). As part of smart cities designs, designers utilize mobile

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cloud computing, electronic objects, networks, sensors, and machine learning technologies for the different components to interact and communicate with one another. This integration of Internet of Things (IoT) technologies and smart city implementations has garnered substantial attention from researchers, practitioners, and policymakers alike (Siokas et al. 2021). This paper presents a comprehensive exploration of these two interconnected realms, aiming to provide a holistic understanding of their significance, applications, and potential for reshaping modern municipalities in the form of a systematic literature review (Keshavarzi et al. 2021).

Considering the rollout of technology, smart cities, contemporary municipal development, and a planning concept, can provide municipal gains. Likewise, a smart city allows data exchange, interaction, and combining services whenever and wherever necessary. To increase the efficiency and effectiveness of service delivery and management, governments all over the world increasingly rely on information and communication technologies (ICTs) (Din et al. 2019). ICT-based innovation would revolutionize and rewire the traditional ways of managing municipal systems through the application of ICTs in smart cities, which will enhance urban infrastructures technologically and improve the quality of life and solve sustainability concerns. As development accelerates, harnessing the power of IoT has become crucial for addressing municipal challenges such as traffic congestion, energy consumption, and environmental sustainability (Mehmood et al. 2017).

Simultaneously, the implementation of smart city frameworks has emerged as a strategic approach to orchestrate municipal development in a holistic manner. Smart city frameworks encompass diverse dimensions, including mobility, governance, economy, environment, and quality of life as shown in Table 1 (Desdemoustier et al. 2019; Giffinger & Kramar 2022). These frameworks guide municipal planners, policymakers, and other stakeholders in aligning their efforts toward creating well-coordinated, resilient, and citizen-centric municipal spaces. Thus, in a series of studies, it was found that empowerment and inclusion of citizens can unlock smart-sustainable municipal development that emphasizes environmental protection and social equity rather than just reinforcing neoliberal forms.

While both IoT technologies and smart city frameworks hold immense potential, their successful integration requires a deep understanding of their intricacies, challenges, and synergies. This paper embarks on a systematic exploration of these areas by conducting a thorough literature review and analysis of relevant studies. The objective is to shed light on the current state of research, identify key trends, and provide insights into the evolving landscape of IoT and smart city implementations within municipalities (Karuri-Sebina & Guya 2020).

Through the examination of literature on IoT technologies, communication protocols, machine learning applications, and real-world smart city initiatives, this study seeks to contribute to the growing body of knowledge in the field. By unveiling the intersection of these two transformative domains, this paper aims to offer a comprehensive perspective on how IoT frameworks and smart city implementations can jointly shape the municipal landscape, improve the quality of life for residents, and foster sustainable municipal development (HamaMurad et al. 2021).

Table 1. Key Dimensions and Primary Indicators for Smart Cities, quoted from Giffinger and Kramar (2022).

Domain	Indicators
Smart Mobility	Public Transport, Technology and Innovation, Sustainability and Environmental Impact and Clean-Energy Transport
Smart People	Education, Population, Inclusion and Creativity
Smart Living	Healthcare, Security and Safety, Culture, and Housing
Smart Governance	E-governance, Internet and Wi-Fi Coverage and Disaster Preparedness
Smart Economy	Start-ups, International Collaboration, Low Poverty Rate and Job Opportunities
Smart Environment	Green Spaces, Air Quality and Low Pollution, Energy Use, Water, Waste Generation and Biodiversity

Planning continues with defining the key research question that will guide this project since the research question influences several steps throughout the entire process. The paper aims to answer the following research question: *What does the literature say about the extent to which and in what ways smart cities frameworks are deployed within municipalities initiatives globally?* Finally, the objectives of the work reported here were for example: To investigate the landscape of IoT frameworks for smart cities and analyze their technological components and communication protocols. To critically assess the applications of machine learning in securing IoT devices and enhancing smart city functionality. To explore different smart city implementation frameworks adopted by municipalities worldwide and analyze their key dimensions for urban development.

2 Methods

This research work follows systematic literature review principles to achieve its purpose and its corresponding objectives, which are presented in the Introduction. Systematic literature review, also known as systematic review, aim at identifying, evaluating, and interpreting all available research relevant to a particular problem, topic, or phenomenon that needs to be addressed, as described by Kitchenham and Brereton (2013). Similarly, systematic literature review is defined as a systematic, explicit, comprehensive, and reproducible method for identifying, evaluating, and synthesizing the body of completed and recorded work of researchers, scholars, and practitioners in Okoli and Schabram (2010). Considering Kitchenham and Brereton (2013) approach to systematic literature review, the present study adopted the systematic literature review methodology to aid in the planning, searching, screening, extracting data, and synthesizing and reporting of findings.

2.1 Searching Strategy for the Literature

To provide a comprehensive picture, various academic databases, digital libraries, and search engines from both academic and open access sources have been explored as the first step. Among the databases investigated were some renowned online scientific databases, including Web of Science, Scopus, Institute of Electrical and Electronics Engineers Xplore, AIS (Association for Information Systems Library), Springer, and ProQuest, as well as popular ones like Semantic Scholar, MDPI, and Google Scholar. After several challenges encountered regarding the other mentioned databases, the study adopted the adoption of Google Scholar and Web of Science databases. According to Falagas et al. (2008), Google Scholar has some weaknesses, such as the lack of accurate citations and duplicate references, among others. As an example, they contend that its free access makes it a valuable option for researchers on a budget, integration of the PubMed database, and ability to list the most cited articles first cannot be ignored. The Web of Science, on the other hand, offers better graphics and more detailed citation statistics. Using Boolean search strategies AND, OR operators and advanced search strings, the following search strings were used to retrieve the required research articles from databases.:

((Smart Cities AND Internet of Things) OR (Machine learning AND Internet of Things)), ((IoT AND IoT Security Attacks) OR (machine learning AND IoT AND security)), (Security Issues in IoT Layers AND Security Issues in IoT Architecture), ((IoT AND Smart cities frameworks globally) OR (IoT frameworks AND Smart cities frameworks) OR (smart cities)) and ((IoT) OR (IoT AND municipality)).

Among the papers considered were those published between 2010 and 2023 in journals and conferences which included the previously mentioned phrases and related user studies. The aim was to gather scholarly papers published within the last decade, to ensure that the materials collected are as up-to-date and relevant as possible, and coincide with the digital age, as well as the era when IoT and smart cities are becoming increasingly prevalent.

2.2 Criteria for the Selection

According to Table 2, the results of the articles search process were thoroughly screened using pretest criteria for inclusion and exclusion. Firstly, with the inclusion criteria, considerable effort was made to ensure that only published articles from 2010 until 2023 were considered. This was to ensure that interventions and applications related to IoT frameworks and smart cities frameworks for municipalities were kept up to date and relevant. Secondly, all articles were carefully assessed to make sure they were peer-reviewed articles and that they discuss IoT frameworks implementation in terms of smart cities. Lastly, only those articles that met the criteria of relevance, uniqueness, available online and written in English language were included in the review.

In relation to exclusion criteria, the abstracts of many papers revealed that they did not actually make use of IoT frameworks or did not apply smart city framework concepts to municipalities and were therefore eliminated. Also excluded were studies that did not

discuss IoT frameworks, municipalities, smart cities frameworks, or cyber security in smart cities. A similar exclusion applied to IoT framework studies that are not available online, peer-reviewed journals, distinctive, book chapters, or conference papers, and smart cities frameworks within municipalities.

Table 2. Inclusion and exclusion criteria for primary studies.

Inclusion	Exclusion Criteria
Addressed the implementation of IoT and smart cities frameworks for municipalities	Addressed related concepts that were not IoT and smart cities frameworks for municipalities
Published between 2010 and 2023	Published before 2010
Written in English	Non-English publications
Peer-reviewed journal, conference papers and seminal works	Papers that are not peer-reviewed (e.g., proposals, theses, related publications such as book chapters and ongoing projects)
Original publications	Duplicated papers
Publications available online	Publications not available online

2.3 Results of the Search

To collect the relevant papers, the search was performed based on both identified databases as well as keywords, as shown in Fig. 1. It was found that Google Scholar and Web of Science (WoS) databases listed 310 and 120 academic publications respectively and 430 in total, searched between January 2022 and June 2023. 176 articles were excluded from this analysis, since these papers are frequently indexed in multiple databases. Thus, a total of 254 articles were resulting from 218 articles from Google Scholar and 36 articles from WoS. The review of these articles exposed 72 duplicates out of 254, which were removed. This resulted in 182 articles being identified during the identification process. Screening the titles, abstracts, introductions, and conclusions of 182 articles led to the researcher finding that a further 82 articles were of no relevance to the current study. There were therefore 100 remaining articles. During the eligibility stage, all 100 articles were carefully reviewed. This review does not cover 61 of these articles because they address different issues regarding IoT and smart cities frameworks implementations. In summary, 39 articles qualified as meeting the inclusion criteria and definitions in this systematic review.

An overview of the distribution of selected papers by their publication year is shown in Fig. 2. According to the diagram, municipalities are increasingly using IoT frameworks and smart cities frameworks to implement projects, and the two concepts had not been combined until 2010. A significant increase in publications was observed after 2014, with 17 significant papers published in 2021 and 8 in 2022.

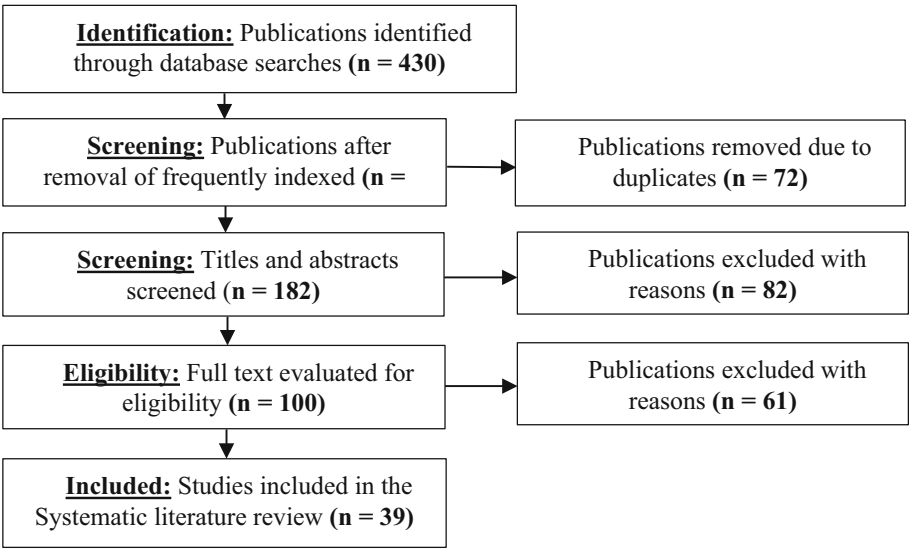

Fig. 1. The systematic literature review process diagram

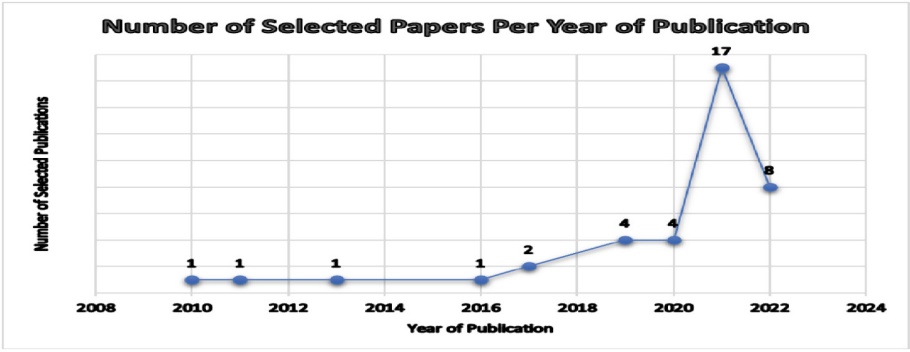

Fig. 2. Line chart depicting the number of published papers per year.

2.4 Extraction of Data

This phase involved analyzing each article individually to determine final inclusion in the systematic literature review, which was a two-part process called screening and eligibility. Each article was screened independently, but a great deal of effort was put into minimizing bias. To determine whether the obtained articles addressed the objective of this study, the first step screening involved scanning the titles, abstracts, introductions, and lastly conclusions. For the second stage eligibility, comprehensive literature reviews were conducted by skimming through and subsequently reading full texts to collect relevant data for a systematic literature review. To carefully assess each study, the following quality assurance criteria were used: what was the application area? What type of data was collected? What methodology was used? Where was the study based? and what

type of study was carried out? Accordingly, the articles were categorized according to two primary topics: IoT frameworks for Smart Cities and Smart city implementation frameworks within municipalities globally. Finally, excel spreadsheets were developed to record data systematically and accurately. Table 3 lists the articles classified in each area.

Table 3. Articles classified according to each topic area.

Internet of Things	Implementations Globally
D'Amico, Szopik-Depczyńska, Dembińska, and Ioppolo (2021)*	Bastidas, Bezbradica and Helfert (2017)
Din, Guizani, Rodrigues, Hassan, and Korotaev (2019)	Bellini, Nesi, and Pantaleo (2022)
El-Hajj, Fadlallah, Chamoun and Serhrouchni (2019)	Cisco (2022)
Ghaffar, Alshahrani, Fayaz, Alghamdi, and Gwak (2021)	D'Amico, Szopik-Depczyńska, Dembińska, and Iop-polo (2021)*
Hussain, Hussain, Hassan, and Hossain (2020)	Gheisari, Najafabadi, Alzubi, Gao, Wang, Abbasi, and Castiglione
Imran, Zaman, Imtiaz, Fayaz, and Gwak (2021)	Giffinger and Kramar (2022)
Li, Yang, Yang, Wang, and Wu (2019)	HamaMurad, Jusoh and Ujang (2021)
	Hamzah, Adnan, Daud, Alias, and Dali (2016)
Majid, Habib, Javed, Rizwan, Srivastava, Gadekallu, and Lin (2022)	Khatibi, Wilkinson, Baghersad, Dianat, Ramli, Suhatril, Javanmardi and Ghaedi (2021)
Mokoena and Sebola (2020)	Kourtit (2021)
Nurlan, Zhukabayeva, Othman, Adamova, and Zhakiyev (2021)	Moustaka, Maitis, Vakali, and Anthopoulos (2021)
Qin, Hu, Liu, Witherell, Wang, Rosen, Simpson, Lu and Tang (2022)	Razmjoo, Gandomi, Mahlooji, Garcia, Mir-jalili, Rezvani, Ah-madzadeh and Memon (2022)*
Razmjoo, Gandomi, Mahlooji, Garcia, Mirjalili, Rezvani, Ahmadzadeh and Memon (2022)*	Muthaiyah and Zaw (2021
Shrestha (2022)	Tang, Jayakar, Feng, Huiping and Peng (2019)Tzioutziou and Xenidis (2021)
Siokas, Tsakanikas, and Evangelos (2021)	
Vaigandla, Karne and Rao (2021)	

* There is more than one issue covered by articles marked with an asterisk.

2.5 Synthesis

A thematic synthesis approach was adopted for this systematic literature review since it covered an array of academic disciplines and fields. A data synthesis approach such as this can be particularly useful for identifying, analyzing, synthesizing, and reporting multidisciplinary datasets, as Cruzes and Dyba (2011) argue. A detailed conclusion was drawn based on the analysis of recurring themes across the included studies to accomplish the study's main objectives. To compare the perspectives and findings from the included studies, the identified IoT frameworks and smart cities framework implementations were seen as starting points. To develop distinct themes from the selected studies, IoT frameworks and smart cities framework implementation and interventions in municipalities served as common concepts.

3 Results

It appears that the number of publications relating to smart cities has increased between 2010 and 2022, according to this systematic literature review. Technological advancements and smart cities are likely to have contributed to this drastic increase. An unusually constant number of publications related to IoT, and smart cities frameworks for municipalities have been published between 2019 and 2023. Following are the sections that detail various applications and aspects of IoT frameworks and smart cities frameworks papers for municipalities. These include IoT frameworks for smart cities and smart city implementations frameworks within municipalities globally.

3.1 IoT Frameworks for Smart Cities

According to the results of this segment, examples of IoT implementations within smart cities fall into a variety of categories, including IoT technologies and machine learning in IoT. By comparing them based on goals, methods, and chronology, this systematic literature review provides a critical analysis of these categories.

IoT Technologies. Some existing IoT technologies and communication protocols utilized to connect physical devices and virtual objects identified by Vaigandla et al. (2021) and Ghaffar et al. (2021) include the following: Bluetooth and Bluetooth Low Energy, which, in contrast to other wireless protocols, is found to be a reliable, afford-able, and low-power protocol that is widely implemented for short-range communications in IoT systems for transferring data wirelessly (Vaigandla et al. 2021). Developed as a global connectivity standard for IoT data networks, Zigbee is a wireless technology allowing for low-cost, security, high scalability, and low-power wireless net-work connections, according to Imran et al. (2021). Similarly, Long Range Wide Area Network (LoRaWAN) is referred to as Low-power, Low-Cost, Mobile, and Secure Wireless Technology by Vaigandla et al. (2021) and Ghaffar et al. (2021), this is due to its ability to optimize for scalable networks with millions of wireless devices with low power consumption and very low cost. Furthermore, it can detect signals under the noise level over long distances, allowing IoT applications to detect low-strength signals.

Machine Learning in IoT. The application of machine learning to real-life problems has become a focus of computer scientists in recent years. As defined by Broderick et al. (2023), machine learning involves detecting patterns in data and using the patterns to predict future data, uncertainty, or making decisions under a certain set of circumstances. For instance, to estimate the transmission effect of innovation, Li et al. (2019) used machine learning. A study by Qin et al. (2022) unearthed that machine learning technologies have demonstrated their effectiveness in a variety of industries, such as computer science, aviation, healthcare, and manufacturing. Corporate management currently uses machine learning methods to optimize production processes (Li et al. 2019). Hussain et al. (2020) identify some of the security related real-world applications that are applicable within machine learning, namely but not limited to: 1) Machine Learning (ML)-based authentication and access control in IoT, 2)ML-based attack detection and mitigation in IoT, 3)ML-based techniques to address Denial of Service (DoS) and Distributed Denial of Service (DDoS) attacks in IoT, 4) ML-based IDS in IoT, and 5)ML-based malware analysis in IoT.

3.2 Smart City Implementation Frameworks Within Municipalities Globally

The application of new technologies has, according to Giffinger and Kramar (2022) become crucial in many dimensions, requiring an increase in energy efficiency, the mitigation of emissions, and facilitating new forms of communication. Hence, many municipalities are embracing new technologies as important tools for municipal development to meet the new challenges comprehensively. The goals, objectives, and indicators of the municipality should be the focus of this (Bastidas, et al. 2017).

European Smart Cities (ESC) approach is a concept developed by Giffinger et al. in 2007 and adapted by Giffinger and Kramar (2022). The duo highlighted six key domains (Smart Mobility, Smart People, Smart Living, Smart Governance, Smart Economy, and Smart Environment) of municipal development in this study. As a result of the ESC approach, municipalities can know how to coordinate better, draw mutual lessons, and exchange best-practice examples (Moustaka et al. 2021), while also tracking progress and planning improvements over time (Giffinger & Kramar 2022). This was to gather insights on data-driven individual city profiles to provide a clear picture of understudied municipalities at different levels of detail, thus effectively leading stakeholders to uncover what smartness means (HamaMurad et al. 2021). The empirical evidence was not only provided in relation to municipality profiles in a differentiated manner because of this approach, but also groups of cities with similar profiles were identified. Likewise, Razmjoo et al. (2022) completed, categorized, and examined research publications based on extensive review of literature that focuses on the problems and solutions of several key sectors that have significant implications for smart cities development, such as public transportation, utilities, street lighting, waste management, public safety, and smart parking. As part of the analysis, they looked at important cities within the European Union (Paris, London, Copenhagen, Barcelona, Amsterdam, and Oslo) and in the USA (Boston, New York, and San Francisco) that are relevant to the IoT. Razmjoo, et al. (2022) provide a summary of a few core ideas related to the three dimensions, presented in Table 4.

Table 4. IoT barriers and appropriate solutions for the development of smart cities, summarized from Razmjoo et al. (2022)

Sectors	Challenges Confronting Municipalities	IoT-led Solutions
Public transport	Private cars create noise in cities, citizens' transportation unmonitored and unsafe; traffic congestion increases CO2 emissions	Smartphones, monitoring sensors can assist in improving the quality of roads
Street lighting	The absence of sensor-equipped streetlights and the presence of defective streetlights	The use of sensors in streetlights, switch to reduce light output, and low-energy bulbs
Utilities	Fuel and electricity wasted, fuel and electricity expenses, smart meters and smart billing, consumption patterns, and limited consumption monitoring	Quality of services improvement by using smart meters, proper consumption patterns, and management services
Smart parking	Parking limited or non-existent, cars parked improperly on the street, and traffic narrows routes	Using drivers' smartphones or embedded sensors to determine location

Through a systematic literature review, D'Amico et al. (2021) created a Smart and Sustainable Logistics in Port Cities framework that holistically integrates a variety of enabling factors, domains, and goals that frame smart and sustainable logistics in port cities. The proposed framework highlights the following enabling factors: Both (1) Ecosystems and (2) Organizations, emphasize an active role and organizational flexible interaction among various stakeholders, including port managers, planners, administrators, entrepreneurs, citizens, couriers, students, port authorities, road and rail transport companies, technology companies, financial institutions, etc., (3) Data and Security, and (4) Policy and Regulation, underscore the complexity of digital technologies, with security levels that encompass data and information from multiple stakeholders. Accordingly, (5) Finance and Funding highlights the importance of tax leverage to trigger worthy logistics developments. Through the support of technology companies such as Cisco, IBM, SAP, Ericsson and Huawei, an in-depth analysis of several pioneering port cities was carried out, including Amsterdam, Rotterdam, Antwerp, Los Angeles, Valencia, Hanan, Montreal, Stockholm, Hamburg, Singapore, etc. (D'Amico et al. 2021). For example, with Cisco Edge Intelligence software, the Port of Rotterdam used a multi-cloud dashboard to analyze, interpret, and refine data from patrol vessels to improve logistics and operations (Tang et al. 2019; D'Amico et al. 2021). Likewise, as part of IBM's logistics infrastructure solutions, sensors, IoT platforms and Augmented Intelligence platforms were integrated into the logistic infrastructures, enabling them to collect, process and provide data on weather, berth availability, and other statistics (Tang et al. 2019; D'Amico et al. 2021). In addition to improvements in information collection, processing, monitoring, analysis and evaluation, the framework enhances the smartness and sustainability

of urban and industrial processes by harmoniously integrating mobility, economy, governance, environment, telecommunications, health, safety, and so on, as according to D'Amico et al. (2021) and Bellini et al. (2022).

In their study Muthaiyah and Zaw (2021) developed Overarching Autonomous Learning Framework (OALF), in this model they consider key layers such as acquisition, data, business, and application architectures. Their model addresses the making of a city to being smart, with an emphasis on business architecture having autonomy and self-learning capabilities. According to the pair, smart capabilities need to be able to reason and act independently with very little or no human involvement, to be deemed smart, a device or system must be capable of thinking independently in difficult situations. Two technologies, IoT and artificial intelligence (AI), made this possible (Muthaiyah & Zaw 2021). They used this framework to measure the interest in promoting assessment of social well-being in addition to psychological and emotional well-being among others.

Moreover, Hamzah et al. (2016) created Reconciled Smart City Assessment framework that incorporates, enforces, and improves, the validity of its operations as seen in Fig. 3. In essence, the authors revealed that the development of this framework provides a thorough insight into the assessment of a municipality's smartness that should be based on: (1) six imperative smart city dimensions; (2) the unique main functions of the specific city; (3) the planned/prioritized smart initiatives; (4) actual requirements of the city stakeholders and subsequently smart initiatives of the inhabitants (Hamzah et al. 2016). Meanwhile the concept of municipal resilience can be seen as serving the goal of sustainability and has a similar operational framework as that of smart cities, in terms of operationalizing resilience, the smart city model appears to be instrumental given the importance of the technological dimension (Tzioutziou & Xenidis 2021; Khatibi et al. 2021). According to the finding, resilience thinking is the theoretical background, while smart city solutions are the design requirements, pointing out the specific roles of the two concepts in the emerging integrated framework (Tzioutziou & Xenidis 2021).

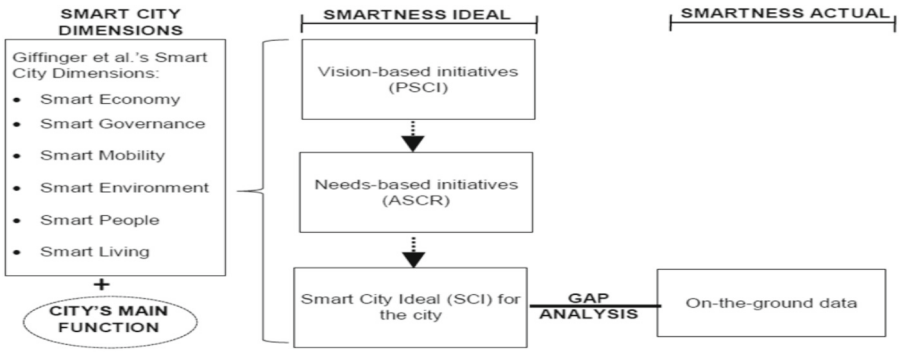

Fig. 3. The Reconciled Smart City Assessment Framework (RSCAF)

4 Discussions

This systematic literature review shows that digital technologies and their frameworks play a fundamental role in the development of a variety of systems and infrastructures for the efficient and effective development of municipalities in different parts of the world as smart city initiatives are undertaken. Such technologies allow better resource management, increased public safety, and improved quality of life for citizens. They also provide opportunities for more sustainable and resilient municipalities. Moreover, they enable data-driven decision making and optimize municipal operations. Despite the study focusing on smart cities frameworks, two major areas where recent scholars have looked were identified, namely: IoT framework implementation for smart cities and smart city implementation frameworks in municipalities around the world.

4.1 IoT Framework Implementation for Smart Cities

According to Vaigandla et al. (2021), Bluetooth and Bluetooth Low Energy are a great tool for smart cities since they are free from open firmware and hardware standards, and they have many advantages over their competitors when it comes to short-range wireless data transmission in IoT systems. BLE has many advantages, including the fact that it does not support open firmware and hardware standards. Zigbee provides seamless Internet connectivity throughout municipalities without sacrificing power or cost, Imran et al. (2021) found. It also enables easy control of thousands of devices, which adds value to the municipalities. In the same light, El-Hajj et al. (2019) on the other hand highlighted the importance to maintenance of data privacy, confidentiality, and secure communication to the IoT architecture, and indicated that sharing of details should respect the privacy of the individual through enforcement of the privacy regulations regarding the collection of data and its storage in memory. As Ghaffar and colleagues (2021) noted, the important aspect of IoT platforms is using the transmission control protocol (TCP) and non-TCP protocols to identify connected things using unique addresses to identify them. The study also revealed that diversifying complementary networks and devices also helps to accelerate adoption; in this regard, both municipalities must have their own network capacities and usage. Moreover, Qin et al. (2022) revealed that machine learning technologies have demonstrated their effectiveness in a variety of industries, such as computer science, aviation, healthcare, and manufacturing. Furthermore, several key security features were outlined in Din et al. (2019) study for IoT-based devices. These features include identity and authentication, data encryption, and secure communication. Additionally, the authors recommend implementing a secure update system, and using two-factor authentication. Finally, they suggest using threat detection and vulnerability assessments to identify potential security issues. Nurlan et al. (2021) highlighted those applications embedded with sensors, software, networks and other related IoT technologies like smart surveillance systems, smart homes and so forth, are associated with smart cities. They emphasized that these technologies provide valuable insights into how municipalities operate, how resources are used, and how citizens interact with their environment. Moreover, they recommend that this data can be used to create more efficient services, improve public safety, and reduce energy consumption. Essentially, Siokas et al. (2021) suggested that policymakers should consider the uncertain social,

financial, and cultural environment and the needs of all stakeholders when formulating a policy strategy. Furthermore, they considered the potential implications of the policy on minority groups and vulnerable communities. The policy should also be tailored to the specific needs and conditions of each city. Finally, they posit that policy should be implemented in a way that promotes sustainability and protects human rights.

4.2 Smart City Implementation Frameworks in Municipalities Around the World

The paper identifies and classifies smart city concepts that are used by different municipalities to answer the research question. As well as meeting requirements for smart city development compared to conventional municipal processes, these concepts must also be compatible with the smart city vision and be compatible with it. We then analyze the relationships between these concepts and smart city goals. Several studies included in this research, including Giffinger and Kramar's European Smart Cities (ESC) developed in 2007 and adapted by the same authors in 2022, have identified six key domains of city development (Smart Mobility, Smart People, Smart Living, Smart Governance, Smart Economy, and Smart Environment). Based on the ESC approach, the Planning for Energy Efficient Cities (PLEEC) project has demonstrated that basic conditions like population densities are entirely different in a city like Jyväskylä (a city surrounded by lakes and forests), as opposed to Santiago de Compostela (a touristic Spanish city with a historic center) or Stoke-on-Trent (a city with a long industrial history). Considering that comparing cities based on single characteristics always requires consideration of regional and historic contexts, it is highly advisable not to discuss single indicators, but only the average of combined characteristics at the domain or field level, for a more reliable basis on which strategic policy advice can be formulated. To complement the studies included in this systematic literature review, similar studies have also been conducted in other contexts. For example, after evaluating their framework, namely Smart and Sustainable Logistics in Port Cities, D'Amico, et al. (2021) concluded that the framework can provide the following smart cities areas indicators benefits: Ecosystems and organizations, stakeholders flexible interaction, including port managers, planners, administrators, entrepreneurs, citizens, students, transportation companies, technology companies, financial institutions, data and security, policy, and regulation. As such, a collaborative approach is important for the development of a smart city in the sense of a smart sustainable city, according to them. Similarly, Razmjoo et al. (2022) analyzed, and categorized research publications based on an extensive literature review addressing several key sectors with significant impacts on the development of smart cities, including public transportation, utilities, street lighting, waste management, public safety, and smart parking. Also, a comprehensive analysis of several pioneering port cities, including Amsterdam, Rotterdam, Antwerp, Los Angeles, Valencia, Hanan, Montreal, Stockholm, Hamburg, Singapore, was conducted with the support of technology companies such as Cisco, IBM, SAP, Ericsson, and Huawei (D'Amico et al. 2021). Furthermore, Muthaiyah and Zaw (2021) emphasized the importance of the OALF framework that they say can be used to measure the interest in promoting assessment of social well-being in addition to psychological and emotional well-being among others. Kourtit (2021) recommended that CSF framework can likely assess the livability conditions of but not limited to districts, neighborhoods, or even individual streets in modern cities, to obtain a detailed

picture of sustainable, healthy, and safe urban environments, as well as achievements related to health, safety, cohesion, and governance. Gheisari et al. (2021) illustrated how with OBPP, IoT-based smart city devices can be subjected to privacy rules, and abnormal conditions are identified while heterogeneity issues are addressed. Hamzah et al. (2016) examined and investigated RSCAF in further detail, concluding that resilient and smart city frameworks have some fundamental characteristics in common, enabling the development of a unified concept rather than two separate approaches to municipal development.

5 Conclusions

The paper reviews IoT frameworks and smart city frameworks implementation in global municipalities. An elaborate systematic literature review was conducted to highlight the identification, screening, eligibility, and inclusion process, and the results were discussed in detail. Among the 430 works initially extracted, 39 were selected for research based on their relevance to the research question. As a result of the survey of these articles, it is concluded that the integration of IoT frameworks and smart city frameworks will result in a range of innovative smart city concepts, including smart living, smart people, smart economy, governance, and mobility, which are aimed at quality-of-life improvement for citizens. Most of these contributions are noteworthy; however, more work is needed to optimize them, thus opening new research opportunities for those interested in the topic. Through such research, new technologies can be developed, and existing ones can be improved, providing industry and academia with new opportunities. There are no doubt that industrial and academic fields will have a close connection despite any tension. It is shown that smart cities that adopt these technologies and remain interconnected are susceptible to a host of cyber security threats, including privacy and confidentiality breaches, physical threats, vulnerabilities in systems and applications, malware injections, denial of service (DoS), malicious insider threats, and data leaks. Furthermore, these efforts may also provide insights into interdisciplinary approaches that can be applied to other fields.

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