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SMART CITIES IN SERBIA: A SYSTEMATIC REVIEW WITH SWOT AND TOWS STRATEGIC INSIGHTS

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ABSTRACT

Different urbanization rates all over the world, environmental pollution and digital transformation lead to the emergence of the term "smart city". According to the definitions, smart cities are urban environments in which residents can use modern technologies to make informed decisions, improve their quality of life, and actively participate in city-level decision-making processes. In Serbia, scientific research, implementation of smart technologies and development of smart cities are mostly done in an unstructured manner, with numerous spatial disparities. In this paper, a systematic literature review was conducted in order to assess current trends and key topics of scientific research. Furthermore, SWOT and TOWS analyses were conducted to structure the current state of the smart cities development in Serbia and provide insights into possible future development pathways. The results show that there are numerous projects and studies regarding this topic, and that many municipalities and cities have adopted some smart technologies. Nevertheless, the lack of systematic planning, funding and limited human capital remain the main obstacles to the development of smart cities. Future strategies for smart cities development should focus on resolving these weaknesses and threats through strengths and opportunities, such as the willingness of the citizens to participate in decision-making processes, integration of the younger population in scientific and institutional projects, and stronger cooperation among national and international institutions.

Key words: *smart cities, smart technologies, urban development, SWOT, TOWS, Serbia*

INTRODUCTION

In the context of contemporary urbanization, marked by rapid population growth and increasingly complex challenges of sustainable development, the concept of "smart cities" has emerged as a response to the need for integrating economic, social, and environmental stability (Cimbaljević & Dunjić, 2023; Mujević, 2024). According to projections, by 2050, approximately two-thirds of the global population will live in urban areas, while cities will generate around 90% of the world's GDP (World Bank, 2023). In this way, urban areas are becoming not only centers of economic productivity but also hotspots of complex socio-ecological pressures (Đerčan et al., 2019;

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Savić et al., 2022). Within contemporary theoretical frameworks, the smart city represents an evolutionary phase of urban development in which informatization, digitalization, and urbanization converge into an integrated model of governance based on data, technologies, and human resources (Zeng et al., 2023). However, global urban trends show that urban development is far from uniform: while some cities grow, many others undergo demographic, economic, and functional decline — a process that has become widespread since the industrial era (Pogrmić, 2025), further complicating the application of smart concepts across different contexts (Hajduk, 2020; Faliagka et al., 2024). This highlights the need for smart governance models grounded not solely in assumptions of growth but also in adaptation to long-term negative trends (Beretta & Bracchi, 2023). These approaches, defined by Mykhnenko (2023) as "smart decline" or "planning for decline," influence the development of smart city concepts and modern approaches to urban planning, challenging traditional expansion-oriented strategies (Powe & Oswell, 2022).

Over the past decade, the development of smart cities has been closely linked to digital transformation, environmental sustainability, and major global development frameworks, including Sustainable Development Goal 11, the EU Digital Agenda, and the European Green Deal (United Nations, 2015). Accordingly, the contemporary conceptual framework emphasizes data governance, integrated public policies, and active citizen participation as key components of smart city development (Fadhel et al., 2024; Javed et al., 2022). Digital platforms, sensor networks, energy and transport systems, as well as e-government services, enable the optimization of public services, greater efficiency in spatial–functional organization, and more transparent decision-making processes (López-Baldominos et al., 2024). However, numerous authors warn of accompanying risks such as digital inequality, privacy constraints, and potential social segregation (Ismagilova et al., 2022). About half of EU-28 cities with more than 100,000 inhabitants have already implemented or proposed smart city initiatives, while nearly all cities with over 500,000 inhabitants are classified as smart (European Parliament, 2014), indicating that the concept is predominantly associated with large urban centers. In contrast, urban systems in Serbia are largely composed of small and medium-sized cities, where, according to Prigoda et al. (2022) and Kresović & Vukmirović (2025), the implementation of smart technologies is uneven and often constrained by institutional, financial, and demographic factors. Although individual initiatives have emerged over the past decade, scientific research addressing the specificities and potential for smart city development in Serbia remains scarce and fragmented. Existing studies mostly focus on individual case studies or sectoral innovations, while comprehensive analyses of national trends are lacking, limiting the ability to conduct an integrated assessment of capacities and challenges.

This paper aims to consolidate available knowledge in order to map dominant components and the institutional, technological, and social factors influencing implementation, identify key strengths, weaknesses, opportunities, and threats, and formulate evidence-based strategic recommendations. Methodologically, the paper applies a systematic review approach aligned with contemporary research standards. The review includes peer-reviewed studies indexed in Scopus and Web of Science, as well as strategic and policy documents and relevant grey literature. The findings are interpreted through a SWOT analysis that identifies internal and external factors shaping smart city development, while the TOWS framework is used to formulate strategic directions that link existing capacities with technological and policy opportunities. This study contributes to the literature by integrating SWOT and TOWS analyses, thereby developing a structured and operational strategic framework relevant for decision-makers, local authorities, and urban planners. The findings further highlight the importance of coordinated governance, long-term strategic planning, and continuous investment in digital infrastructure as key prerequisites for advancing the smart city agenda.

The structure of the paper includes: (1) a literature review on smart technologies, (2) the conceptual framework of smart city development, (3) methodology and data collection procedures, (4) results of the systematic review, (5) SWOT and TOWS analysis and discussion, and (6) conclusions with recommendations for future research.

Smart technologies: Architecture, domains and functional capacities

According to Fernandez-Anez (2016), technology plays a key role in the development of smart cities as an operational tool for integrating urban systems and coordinating various actors, although the concept of "smart cities" is often criticized for potential negative effects, such as the replacement of human labor, job loss, and corporate dominance over technological systems (Kummitha & Crutzen, 2017). Nevertheless, such processes require strict data privacy controls and compliance with regulations, such as the GDPR, i.e., the General Data Protection Regulation (European Parliament, 2014). Smart technologies can be classified according to their domains of application, which enables systematic planning, maturity assessment, and prioritization of urban service development, in accordance with ISO 37122:2019 (International Organization for Standardization, 2019). This standard represents a key instrument for internationally comparable measurement of city "smartness" through 81 indicators distributed across approximately twenty thematic areas, encompassing domains of urban services and digitally integrated systems.

In the context of smart cities, the Internet of Things (IoT), through the integration of sensor technologies (RFID, NFC, BLE), smart devices, and big data analytics, enables the collection, processing, and real-time visualization of data for the analysis and optimization of urban processes (Abdul Salam et al., 2024). In urban environments, IoT is used to form intelligent networks that facilitate communication, infrastructure control, fault detection, integration of renewable energy sources, and security functions through self-healing and adaptive architectures (Zanella et al., 2014; Ali et al., 2022). The basic IoT architecture includes devices, gateways/data collection systems, edge IT (pre-processing), and data center/cloud analytics, representing the technical foundation for implementing smart solutions in urban areas and allowing the adaptation of technologies to specific local conditions and requirements (Elloumi & Boukettaya, 2023).

Wireless Sensor Networks (WSNs) and integrated devices, including temperature, inertial (IMU), laser (LIDAR), optical (camera), and geodetic/positioning sensors (GNSS), form the basis for collecting data on the physical environment, where accuracy, energy efficiency, and calibration are critical for their reliable operation (Abdul Salam et al., 2024). WSNs represent a key infrastructure of modern smart cities, enabling real-time data collection and semantically consistent processing of heterogeneous data in domains such as waste management, traffic, autonomous vehicles, energy systems, and environmental monitoring. The small size and low energy consumption of sensor nodes allow deployment in inaccessible areas and monitoring of critical infrastructure under conditions of natural disasters, industrial accidents, and conflict zones (Zhang et al., 2021). The integration of WSNs with multisensor systems and unmanned aerial vehicles (UAVs) extends monitoring capabilities, as UAVs can collect data from field sensors, oversee hard-to-reach areas, and act as relay nodes within the communication network, enabling advanced prediction, response in hazardous environments and detect land use changes (Manojlović Davidović et al., 2026).

In industrial processes, PLCs (Programmable Logic Controllers) and SCADA (Supervisory Control and Data Acquisition) systems are used for managing, supervising, and controlling production processes in real time. Current trends also include the orchestration of autonomous agents, such as robots and drones, which can independently execute tasks and adapt their behavior to environmental conditions. Adaptive smart technologies are particularly significant, allowing systems to learn from data and optimize their performance without direct human intervention. Integration of these systems with CI/CD (Continuous Integration / Continuous Deployment) and MLOps (Machine Learning Operations) frameworks ensures continuous development, testing, deployment, and maintenance of smart applications, resulting in higher reliability, scalability, and efficiency under real operational conditions (Ali et al., 2022). Artificial Intelligence (AI) has a wide range of applications in smart systems, particularly in anomaly detection, predictive maintenance, image and video analysis, and natural language processing (NLP) for user interfaces. AI often works in conjunction with the Internet of Things (IoT), where sensors collect data to feed machine learning models, which in turn enable systems to respond and operate in an intelligent manner (Hajek et al., 2022).

To sum up, contemporary technological advancements allow for smart cities to be effective, efficient, and to contribute to the inhabitants' well-being. However, technologies come with their challenges and limitations. Through the conceptualization of smart cities, the importance of human-technology interaction will be emphasized as the most important aspect of smart city development.

Conceptualization of the smart city

The term "smart city" appeared in the literature as early as the 1990s (Gibson et al., 1992), while the early development of the concept was described using terms such as "networked cities" (Dutton et al., 1987) and "cybercities" (Graham & Marvin, 1999), referring to urban spaces in which information and communication technologies (ICT) are employed as a development strategy. The contemporary evolution of the concept accelerated significantly after 2008, when IBM, through the Smarter Planet initiative, directed attention toward the integration of advanced technologies into urban development (Palmisano, 2008). Yin et al. (2015) traditionally divide the development of a smart city into three phases: the digitization of urban processes, the integration of intelligence through artificial intelligence to support more complex decision-making, and the advanced phase focused on the practical application of technologies and optimization of the user experience. Derzko (2006) identifies six dimensions of smart city development: adaptation, detection, inference, learning, anticipation, and self-organization, where most countries today primarily achieve the domains of detection and partial adaptation, while more advanced dimensions, such as predictive anticipation and self-organizing systems, remain largely limited to the technologically most developed urban environments.

A smart city can be understood as a knowledge-based city that develops through the use and valorization of data and information, both available and generated within the urban environment, with the contemporary smart city paradigm increasingly shifting toward ecological sustainability (Hajduk, 2020; Van der Meer & Van Vinden, 2003; Ramaprasad & Sanchez-Ortiz, 2017; Ferrara, 2015). Mupfumira et al. (2024) group the analytical frameworks for studying smart cities into four categories: human-oriented, technology-oriented, integrated human–technology frameworks, and environmentally focused frameworks. Fernandez-Anez (2016) emphasizes the role of intergovernmental institutions in defining smart cities, highlighting governance, the environment, the social dimension of sustainability, and quality of life as core elements, while economics, mobility, and efficiency play a more marginal role.

Cimbaljević and Dunjić (2023) define the smart and sustainable city as an integrated ecological–technological system based on sensor architectures and open-source solutions, oriented toward a high quality of life, democratic processes, the green economy, and the minimization of resource consumption. According to Nam and Pardo (2011), the smart city concept encompasses three key components: technological, human, and institutional factors. Genuine urban intelligence is achieved only through the integration of sensor data into centralized or federated city platforms, their processing through standardized ETL pipelines, and their interconnection with transport, energy, healthcare, and environmental systems. This integration enables the development of analytical and AI-based management mechanisms, while automated responses, such as dynamic traffic regulation or targeted health alerts, represent the crucial distinction between instrumental detection and true urban intelligence.

Hollands (2008) identifies five key characteristics of the smart city: the integration of ICT into the urban fabric, business-led development and a neoliberal governance approach, an emphasis on human and social dimensions, programs for social learning and capital, and social and environmental sustainability. Contemporary definitions, such as that proposed by Cimbaljević and Dunjić (2023), build upon these characteristics by emphasizing ecological–technological integration, sensor platforms, and the application of analytical and AI mechanisms aimed at achieving a high quality of life, a green economy, and democratic processes.

METHODOLOGY

Literature identification and selection

The primary data source was the Web of Science (WoS) database, selected for its breadth, rigorous indexing criteria, and interdisciplinary coverage. A search in WoS was conducted using the keywords "smart cities Serbia" and "urban technologies Serbia," resulting in the identification of 128 and 71 publications, respectively, totaling 199 records. Using the Analyze Results tool, TreeMap diagrams for the dominant WoS categories were generated and subsequently integrated into a unified visualization (Figure 1). For the purposes of conducting SWOT and

TOWS analyses, the corpus was further narrowed to the 2014–2024 period, up to November 1, 2025, allowing for the tracking of evolutionary patterns within the studied topics. Additionally, a "snowball method" with literature review from Google Scholar was utilized. After automated filtering and manual relevance checks, a final set of publications was obtained, with the selection process illustrated using a PRISMA diagram.

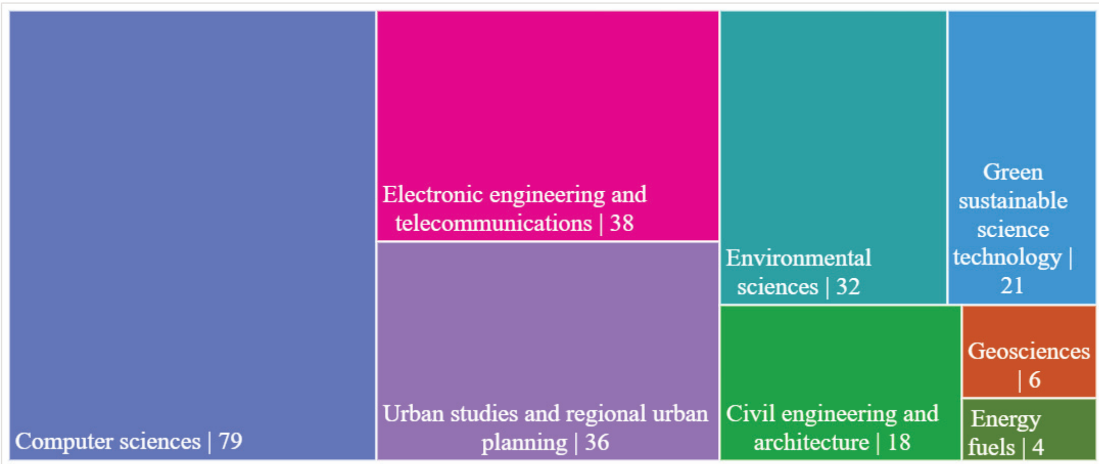

Figure 1. TreeMap Chart of the WoS categories

The systematic literature review (SLR) approach synthesizes existing scientific insights in a structured, transparent, and replicable manner (Snyder, 2019). Its purpose is the comprehensive synthesis and critical comparison of existing findings, the identification of gaps in the literature, and the provision of a basis for policy development and practice improvement (Snyder, 2019; Mupfumira et al., 2024). In this study, the SLR was conducted in accordance with the procedures described by Mupfumira et al. (2024) and Sony and Naik (2020). Firstly, the research titles were screened in order to dismiss the ones which are not strictly related to the smart cities concepts, urban technologies, or Serbian cities. Secondly, the papers that remained were analyzed by reading the abstracts. In the final step, the whole articles were evaluated. After the process of screening, a total of 12 research articles were used in this research.

Analytical approach and SWOT/TOWS analysis

Qualitative literature analysis included thematic clustering of the research papers, identification of the patterns, and synthesis of the information on technological, institutional, governing, infrastructural, economic and social aspects of the smart cities. SWOT and TOWS analyses are types of situational analysis, which can be defined as "critical evaluation of the internal and external environment influencing the system tested, to determine the initial situation before making key decisions on actions aimed at improving the system's position at a given moment in the future" (Žmegač et al., 2024, 26).

SWOT analysis takes into consideration four main aspects in the assessment of the system's current position - Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T). The first two belong to the internal aspects, while the other two belong to external aspects (Ghazinoory et al., 2011; Mupfumira et al., 2024; Žmegač et al., 2024). The advantages of SWOT analysis include its simplicity and flexibility, low implementation costs, and its usefulness as a foundation for strategic development. On the other hand, the main limitation is subjectivity and biases based on the perception of the person making the analysis (Žmegač et al., 2024). Nevertheless, SWOT analysis found its purpose in numerous fields, such as general management, education, marketing, healthcare, agriculture (Benzaghta et al., 2021), spatial planning (Kuzior, Wroński, 2021), as well as smart city frameworks analyses (Mupfumira et al., 2024).

TOWS analysis is the methodology developed with the aim of improving the SWOT and minimizing its limitations. It combines internal and external factors of SWOT, resulting in the TOWS matrix (Table 1) with four strategies: maxi-maxi (SO), maxi-mini (ST), mini-maxi (WO), and mini-mini (WT) (Weihrich, 1982; Žmegač et al., 2024).

Table 1. TOWS matrix (adapted from Weihrich, 1982; Žmegač et al., 2024)

	Internal strengths (S)	**Internal weaknesses (W)**
External opportunities (O)	Maxi-Maxi strategy: Using strengths to maximize opportunities.	Mini-Maxi strategy: Minimizing weaknesses through opportunities.
External threats (T)	Maxi-Mini strategy: Using strengths to minimize threats.	Mini-Mini strategy: Minimizing weaknesses in order to avoid or minimize threats.

Although TOWS gives a deeper understanding of how to utilize all the aspects of the system through combining them, the results of this analysis still depend on the SWOT matrix. Despite the limitations, TOWS is used as frequently as SWOT, due to their complementary nature and broad spectrum of possible uses (Kuzior, Wroński, 2021; Li et al., 2022; Žmegač et al., 2024). The combined approach in this paper enables systematic insight into the potentials and development of the smart cities in Serbia, while also defining the possible paths for their further development.

RESULTS

In this chapter, the first section focuses on the overview of the most notable technological solutions that are currently in use in Serbia, in order to explore Serbia's starting position regarding smart cities development. Subsequently, researchers' interest in key topics and the main findings from the reviewed literature were analyzed.

Smart technological solutions in Serbia

In 2019, Serbia adopted the first sustainable and integrated urban development policy on a national level - Sustainable Urban Development Strategy of the Republic of Serbia until 2030 (SUDSRS) (Government of the Republic of Serbia, 2019; Čolić et al., 2020). As a candidate for the European Union (EU), in this policy, Serbia leaned heavily on previous EU policies on sustainable urban development, such as Urban Agenda for the EU - Pact of Amsterdam (European Commission, 2016). One of the 12 priority topics discussed in this Agenda is digital transition (Government of the Republic of Serbia, 2019).

The main progress on a national level regarding digital transition was made by developing the platform *eUprava* (eGovernment) in 2010. In recent years, it has expanded significantly, with around 2.7 million users of the platform. The main functionalities of the platform include, among others, making appointments for document issuance and applying for kindergarten and elementary schools. One of the website's functionalities related to urbanization is the submission of citizens' comments on the draft public document during the public review process. This feature plays an important role as it allows citizens to submit official complaints from their homes during the public review stage and enhances transparency in the process of adopting major strategic documents (Government of the Republic of Serbia, n.d.).

The research by Stojkov Pavlović (2023) reveals the usage of smart solutions in Cities and municipalities in Serbia for the following indicators: smart and efficient street lighting, virtual heating plant, smart governance, energy efficiency, air quality monitoring, smart public safety, digitalization of water supply network, and smart waste management system. The results show that, among 63 chosen administrative units, 41 have utilized two smart solution indicators, 15 have utilized three of them, 5 have utilized four of them, while the remaining two municipalities have utilized only one smart solution indicator. On the other hand, all the administrative units from this study have smart energy efficiency systems. Smart governance is used by 37 units, and air quality monitoring by 27. The smart waste management system was only used in Belgrade during the trial period in 2019.

One of the examples of the application of smart technologies in cities is the GIS portal of the City of Zrenjanin. On its website, the citizens can get information on cadastral plans and parcels, public and communal services, elementary school areas, public transportation lines, locations of the noise and air quality measurement sites, demographic characteristics of each settlement, special nature reserves, etc. (The City of Zrenjanin, n.d.). Although this website has been a step forward in digital transformation, it does not make the City of Zrenjanin a smart city. Upon a closer inspection, it can be noticed that many of the data (i.e. the demographic data) are outdated or not updated. Secondly, despite having the information on the location of the noise and air quality measurement sensors, there are no real-time data that would help the citizens in decision-making processes, such as not buying a property in a busy street. Furthermore, while the public transportation lines are shown on the map, there is no real-time bus location tracking.

In the light of this example, it can be said that smart cities, in the true sense of the concept, do not yet exist in Serbia (Vasilić, 2018; Čolić et al., 2020; Kisin, Ješić and Vukadinović, 2025). As previously mentioned, technological advances such as sensors and IoT connections do not imply that a city is “smart”. That status is achieved only when the information obtained through the technology is further used by the public (Dahmane, Ouchani and Bouarfa, 2025).

Literature review on the smart cities in Serbia

The literature selection process began in the Web of Science (WoS) database and was carried out in five steps. The initial search in WoS was conducted using the keywords “smart cities Serbia” and “urban technologies Serbia,” resulting in the identification of 128 records. In the second step, only peer-reviewed articles were selected, while conference papers were excluded, reducing the dataset to 74 records. The third step involved screening titles and abstracts, which led to the exclusion of 66 irrelevant records, leaving 8 full-text articles for eligibility assessment. In the fourth step, the snowballing method was applied using Google Scholar, identifying an additional 4 influential articles based on their frequent citation within the selected corpus. The final dataset included 12 publications, forming a thematically coherent and methodologically robust foundation for further analysis. The steps are visually represented through the PRISMA structure (Figure 2).

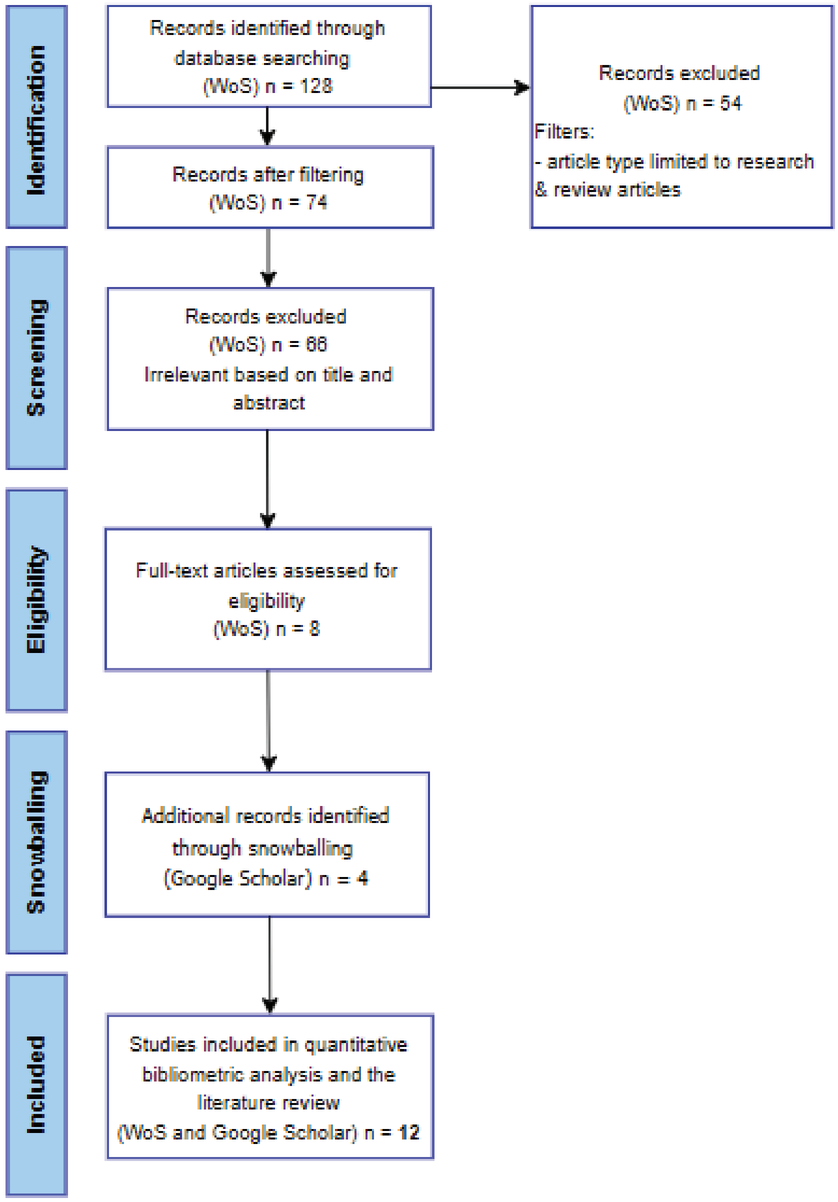

Figure 2. PRISMA structure

Key research themes

To analyze the research themes in the areas of smart cities Serbia and urban technologies Serbia, data from the Web of Science database were imported into VOSviewer in RIS format (Eck, Waltman, 2023). A threshold of at least six occurrences was applied, which enabled the selection of 63 highly relevant terms and the construction of a network with 1,376 links and a total link strength of 6,063, indicating a moderately strong thematic interconnectedness within the corpus. Automatic clustering identified four thematic clusters: the red cluster (core problems and conceptual framework), the blue and yellow clusters (technological solutions and analytical methods), and the green cluster (applications in cities). The most central nodes: city, technology, project, and municipal officials, form a chain linking theoretical challenges with their practical implementation in public administration. Visual representation of the key research themes is given in Figure 3.

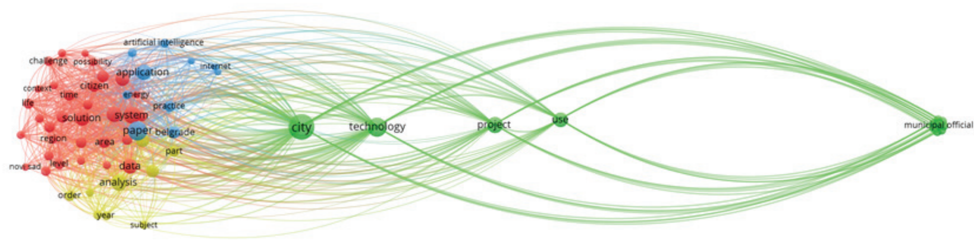

Figure 3. VOSviewer co-occurrence map of terms in research "smart cities Serbia" and "urban technologies Serbia" (2014–2025)

Review of the studies included in the analysis

The literature for this research was divided into four smart city framework categories, based on Mupfumira et al. (2024). The first framework is a technology-centered framework (TCF), which focuses on the technology as a crucial aspect of smart city development, through engaging with the challenges of urbanization through ICT, IoT and other digital innovations. Contrarily, people/user-centered frameworks (PCF) aim to ensure a higher quality of life of the urban population and participatory governance. When combined, the two frameworks constitute a people-techno-centric integrated framework (PTCF). This is the most comprehensive framework, since it relies on human-computer interactions and highlights the duality of the necessities that a city needs to provide to be called a smart city. The environmental-centered frameworks (ECF) represent a separate category, where the priority is put on the integration of sustainable practices with advanced technologies. The goal is to improve urban living and life quality, while also reducing environmental impacts. Table 2 gives an overview of the 12 papers and the framework(s) that were in their research scope.

Table 2. Comparison of smart city research scopes in Serbia

	TCF	PCF	PTCF	ECF
Blagojević et al., 2023				+
Bolesnikov et al., 2024		+		
Čolić et al., 2020		+		
Kisin, Ješić and Vukadinović, 2025	+			
Kovačević, 2022	+			
Milošević et al., 2019			+	+
Pokrić, Kočo and Pokrić, 2014			+	
Šećerov et al., 2019	+			+
Simić et al., 2020	+			
Staletić et al., 2020		+		
Stupar et al., 2019			+	
Vasilić, 2018		+		

The selected papers analyzing technology-centered smart city frameworks can be grouped into two categories: the theoretical and the practical ones. The theoretical papers are Kisin, Ješić and Vukadinović (2025), and Kovačević (2022). In the first paper, the authors summarize the knowledge on twin transition processes (digital and green transition) and the contribution of smart cities to implementation of these processes. Different smart technological solutions, such as eGovernment, were discussed, and it was determined that Serbia has a foundation for the expansion of the smart city indicators. The main suggestions of the authors include digital infrastructure development, electronic communication development, as well as the implementation of legal documents that will strengthen the regulations (Kisin, Ješić and Vukadinović, 2025). Kovačević (2022) compares the smart tools in transportation systems of Copenhagen and Madrid to those used in Belgrade. While it is unrealistic to expect Belgrade to become "the cyclist city" like Copenhagen, it is possible to utilize some positive technological solutions to encourage smart transportation practices. Similar to Madrid, one of the main issues in Belgrade is private vehicles, which make up around 24.32% of the transportation means, while bicycles account for only around 0.75%. With the smart programs of car-sharing or bike-sharing, Belgrade could improve its smart and green transportation practices.

In contrast to theoretical research, practical applications address the study conducted in Abu Dhabi and Belgrade, where Big Data, IoT and networked cyber-physical systems were applied in public safety systems (Simić et al., 2020), and monitoring of urban climate in Novi Sad (Šećerov et al., 2019). Ensuring public safety is a crucial component of smart city development, as it enhances citizens' quality of life, builds trust in digital services, and enables the secure implementation of advanced technologies. Through a multi-sensor imaging system with an AI-subsystem for target tracking detection, accidents or load optimization may be timely detected (Simić et al., 2020).

Monitoring urban climate in Novi Sad was conducted through the network of 28 stations located in the urban area. The goal of the system is to offer early warning notifications of extreme weather conditions, measure human thermal comfort and locate hot spots of the cities. In this case, smart technologies help inform citizens about the city's climate and support better municipal decision-making on climate change adaptation and mitigation (Šećerov et al., 2019).

People/user-centered research papers explore the topics of citizens' readiness for acceptance and implementation of smart city solutions (Staletić et al., 2020; Bolesnikov et al., 2024), frameworks for the urban governance of the smart cities (Čolić et al., 2020), as well as the operationalization of the smart city concept in Serbia (Vasilić, 2018). These studies shift the focus from technology-driven approaches toward a more participatory and socially oriented perspective of smart city development.

The results of the research on citizens' awareness, perceived benefits, acceptance and readiness to participate in smart city decision-making in Belgrade (Staletić et al., 2020) and Novi Sad (Bolesnikov et al., 2024) indicate that the citizens of both cities are willing to adapt to the smart city concepts and technologies. The study by Bolesnikov et al. (2024) highlights the importance of citizens' awareness and knowledge on smart cities, active interest in digital technologies and smart mobility for the integration of smart city solutions. Through their questionnaire, Staletić et al. (2020) outline that the urban population in Belgrade is open to accepting crowdsourcing services related to environmental conservation and public transportation. Both studies point out that these kinds of surveys should be undertaken on a national level to assess the standpoint of the whole population.

Urban governance in smart cities can be explained as a mechanism of utilizing ICT and modern technologies as a means of connecting and networking people/users with information. The study by Čolić et al. (2020) explores the governance practices for smart cities in Serbia, state-of-the-art and possible future challenges. Although Serbia has adopted a national integrated urban policy and numerous local urban development policies exist, the current institutional and individual capacities may not be sufficient for the practical implementation of the policies. The challenges regarding technical aspects of the governance practices include different levels of settlements' development, as well as the need for urban regeneration of numerous urban objects. Nevertheless, the most significant challenges are of a financial and societal nature. Smart cities require substantial investments, significant development funds, and human capital — resources that are increasingly lacking in a country where urban shrinkage represents one of the most critical urban challenges (Ljubenović et al., 2025). Through smart urban governance frameworks, Serbia may overcome the challenges of urban development and integrate the citizens in the decision-making processes.

The indicators for smart cities ranking in Europe based on Griffinger (2007) do not consider the uniqueness of the Serbian settlement network, city sizes, or post-socialistic heritage, which may not be "smart" in the European context, but have employed certain "smart" practices of the time (Vasilić, 2018). Vasilić (2018) compared the factors and indicators for smart cities and smart population, smart economy, smart living, smart management, smart mobility and smart environment assessment. On a European scale, there are 33 factors and 74 indicators for the ranking of smart cities. In Serbia, however, there are 26 factors and 47 indicators available from the official national data, such as the population census. The ranking of Serbian cities based on the smart city concept would benefit local governments, policy-makers and stakeholders by allowing them to make evidence-based decisions and develop strategic plans based on the existing data.

Three papers can be classified into the "people-techno-centered" category. The study by Milošević et al. (2019) indicates that the key measures include defining development strategies and perspectives, ensuring active citizen participation and their engagement in the local community, as well as developing accessible services and e-government. Successful digital transformation is based on the integration of three principles: people (community), processes (identification of "pain points" and optimization of communication between the administration and citizens), and technology (strategic and targeted application aimed at improving efficiency). The authors emphasize that technology in smart cities is not the starting point, but rather a means of creating sustainable communities that operate in accordance with the needs of people and processes.

Another practical paper discusses augmented reality (AR) based smart transportation services in Novi Sad (Pokrić, Kočo and Pokrić, 2014). Main AR system components in Pokrić, Kočo and Pokrić (2014) include: users that interact with the system via mobile phone application, bus stop(s) with QR code, mobile network operator, buses with real-time location trackers, back-end cloud platform for system communication and web portals, which provide secure access to the public transportation company system. This system can be enhanced through the integration of ticket systems, rental bicycles, car parking, etc. A key benefit of AR in public transport is its ability to connect users with the real-time location of public transport vehicles (Pokrić, Kočo and Pokrić, 2014).

Through the pilot project "Creating Accessible Pedestrian Corridors by the Limitless GIS Application" conducted by the Faculty of Architecture, University of Belgrade, and the NGO Limitless in Serbia from 2017 to 2019, the GIS Android application was developed. The goal of the platform was to map accessibility of the roads and pedestrian zones in the urban areas, primarily in Belgrade. The main target groups were people with disabilities, who could input the necessary data into the application, and stakeholders and public sector employees, who could make real changes through the public funds. Some functionalities that the application provides are mapping and evaluation of open spaces, building entrances and building interiors, recommendations, and the possibility to suggest a design and innovation idea on how to improve accessibility. Such applications enable the active participation of citizens in urban decision-making, which represents one of the key principles of smart city development (Stupar et al., 2019).

Environment-centered smart city frameworks have mostly been assessed as a secondary framework in other papers, such as Milošević et al. (2019) and Šećerov et al. (2019). In these papers, the focus is on utilization of smart technologies in urban areas, while the environmental aspects and improvements of the cities were mentioned as a "side effect". The paper that focuses mostly on the environment is the paper by Blagojević et al. (2023). The study area of this research was eight urban areas in the Region of Southern and Eastern Serbia, where the suitability assessment of Nature-based Solution (NbS) for stormwater management was conducted in GIS. Overall, the results suggest that the cities of Leskovac and Vranje are the most suitable for NbS implementation, while Pirot and Bor also have a lot of potential, since they are less densely urbanized and have favourable natural conditions.

Based on the reviewed literature, it becomes evident that a structured analytical approach is necessary to comprehensively evaluate the smart city concept in the Serbian scientific context. Numerous different topics and technologies have been outlined, therefore allowing for SWOT and TOWS analyses on the smart cities in Serbia to be systematically conducted.

Discussion: SWOT and TOWS analyses

SWOT analysis

After a thorough examination of the papers, the SWOT analysis for implementing the smart city concept in Serbia was conducted. The results are given in Figure 4.

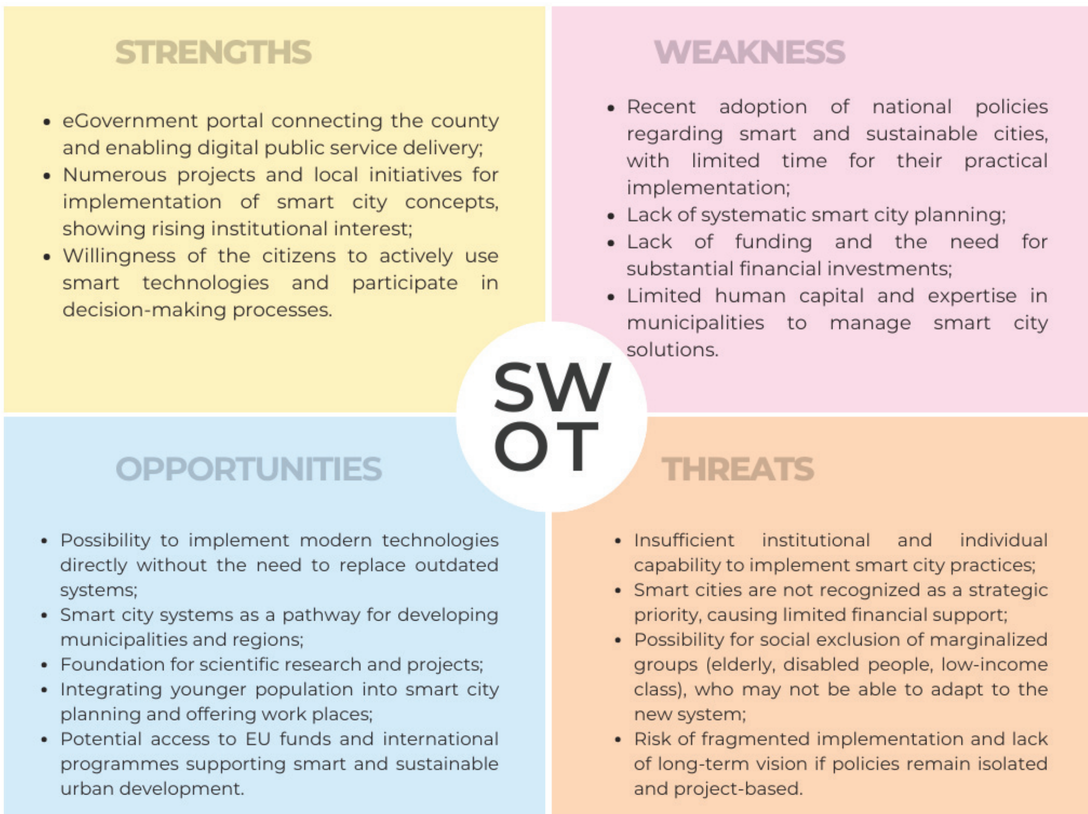

Figure 4. SWOT analysis results
Source: Authors, template adapted from the Internet 1

The most notable strengths for the implementation of smart city concepts in Serbia are the eGovernment system, as well as the existence of numerous national and international projects that focus on this topic (Šećerov et al., 2019; Stupar et al., 2019; Čolić et al., 2020; Simić et al., 2020). Research also shows the readiness of the citizens to actively participate in the decision-making processes (Stupar et al., 2019; Staletić et al., 2020; Bolesnikov et al., 2024). Nevertheless, it must be noted that these three studies have been conducted in Belgrade (Stupar et al., 2019; Staletić et al., 2020) and Novi Sad (Bolesnikov et al., 2024), which are two largest cities in Serbia with a high percentage of younger and economically active population. Vasilić (2018) analyzes 38 medium-sized cities with 40,000 to 180,000 inhabitants in Serbia that belong to the I, II or III category of development. Belgrade, Novi Sad and Niš were not taken into consideration for the research, since they are at a much higher level of development than the other cities in Serbia, and cannot be considered as medium-sized cities. The author emphasizes the differences among the cities, which may indicate that the differences in the willingness of the population to adapt to the new smart city concepts would exist.

Although the existence of the smart city framework and policy on a national level (SUDSRS) is a positive indicator, it has been adopted relatively recently. There is still much more systematic smart city planning to be done. Furthermore, the lack of funding represents one of the main obstacles in developing smart cities, due to insufficient public and national funds for this matter, and also only partial help from the EU (Čolić et al., 2020). Human capital and expertise in smart city planning are scarce resources, since the planning process requires knowledge on geography, spatial planning, law and policy making, economy, technology, but also social sciences, like sociology (Vasilić, 2018).

Smart cities in Serbia may benefit from the late adoption of the new technology. Late adopters can benefit from the experiences and mistakes of early adopters, allowing them to implement more effective technologies with reduced risks and costs (Anthony et al., 2023). Through national or EU projects, scientific research and studies of the cities, much new information and data will be gathered, which may improve the standard of living based on the existing data. Technological advancement is also connected to the younger population, and through different projects, many of them may find financial security and employment.

Despite numerous strengths and opportunities, if smart cities are not recognized as the key pathway for urban development in Serbia and if the government support for the national projects is not sufficient, it will be very difficult to make real changes and improvements. Fragmentary applications of the smart city technologies or favourization of cities like Belgrade or Novi Sad would lead to increased spatial inequality and unequal distribution of resources. Last but not least, marginalized groups of people must be included in the planning of the smart cities to make the cities accessible to everyone.

TOWS analysis

Based on the result of the SWOT analysis, the TOWS analysis was performed. The strategies are given in Figure 5.

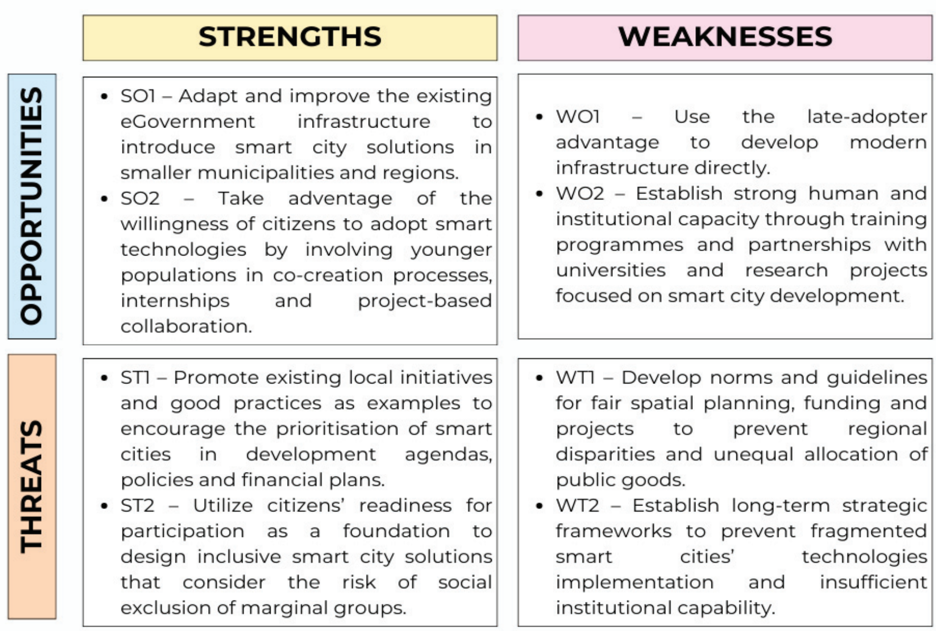

Figure 5. TOWS analysis results
Source: Authors, template adapted from Internet 2

Through TOWS analysis, several strategies have been described. SO strategies focus on the improvement of existing smart cities structures, such as eGovernment, and the utilization of citizens' readiness and willingness to participate in smart city planning. Employing a younger population may contribute to empowering the youth to improve the cities they live in and make a real influence, and ensuring the employment and financial freedom for the struggling (young) adults. Additionally, younger people may bring new, original ideas and perspectives into smart city planning, which could improve the quality of life in the cities.

Given the importance of prioritizing smart city initiatives through institutions, the first ST strategy suggests promotion of the good local initiatives and examples, in order to draw the attention of the stakeholders to their importance. As with SO strategies, ST2 highlights the significance of citizen involvement in spatial planning, with a special regard to the marginalized groups.

WO strategies offer a way to transform weaknesses into development potential. Although Serbia has relatively recently adopted policies on smart cities, this could work to their advantage, since newer, tested technologies may be implemented without the need to change old technology infrastructure. Furthermore, the cooperation between policy-makers, universities, project teams and all other interested parties may improve the human and institutional capacity to implement smart city policies. This could be achieved through employee training programs, joint project applications, international cooperation, etc.

The main objectives of WT strategies are to minimize fragmented and unequal spatial development. In order for this to be accomplished, norms and guidelines that would ensure fair distribution of finances and investments must be established. Long-term strategies regarding institutional capabilities must also be thoroughly thought out, thus decreasing the possibility of framework failures.

CONCLUSIONS

In conclusion, bibliometric and systematic literature reviews helped assess research trends regarding smart cities in Serbia. The increasing and more pronounced trends of publications on this topic highlight the importance of smart cities research in Serbia in the last decade, and indicate possibilities for the practical application of the studied technologies and frameworks. SWOT analysis showed the state-of-the-art of the smart cities' development in Serbia. Subsequently, through combining external and internal factors, the TOWS matrix of strategies was developed to suggest possible advancements in smart cities' development. The key strategies for developing smart cities in Serbia include the planning and regulatory framework for technological advancement that would enable balanced spatial development, as well as securing financial resources and qualified experts to address these challenges.

Future research could focus on applying multi-criteria decision-making methods, such as the AHP technique, to rank the factors of the SWOT analysis and prioritize the TOWS strategies. In addition, field-based research supported by smart technologies could provide valuable insights into real-world implementation, citizens' reactions and opinions, and the practical challenges of smart city development in Serbia.

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