THE ROLE OF ARCHITECTURE IN THE DEVELOPMENT OF SMART CITIES IN SERBIA

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Abstract *This research paper focuses on the role of architecture in the development of smart cities in Serbia, through a comparative analysis with neighboring countries. Although Serbia does not officially have "smart cities," this paper analyzes initiatives and projects in major cities that rely on smart solution principles. Through a comparative analysis with neighboring countries, it investigates key architectural principles relevant to smart cities, analyzes examples from Serbia and the region, and identifies best practices, challenges, and future perspectives. This paper contributes to understanding the complexity and importance of the role of architecture in creating smart cities, and provides guidance for further steps towards the development of sustainable and technologically advanced urban environments.*

Key words: *Smart cities, architecture, Serbia*

ULOGA ARHITEKTURE U RAZVOJU PAMETNIH GRADOVA U SRBIJI

Apstrakt *Ovaj istraživački rad fokusira se na ulogu arhitekture u razvoju pametnih gradova u Srbiji, kroz komparativnu analizu sa regionalnim zemljama. Iako Srbija nema zvanično proglašene "pametne gradove", ovaj rad analizira inicijative i projekte u većim gradovima koji se oslanjaju na principe pametnih rešenja. Kroz komparativnu analizu sa regionalnim zemljama, istražuju se ključni arhitektonski principi relevantni za pametne gradove, analiziraju se primeri iz Srbije i regiona, identifikuju najbolje prakse, izazovi i buduće perspektive. Ovaj rad doprinosi razumevanju kompleksnosti i važnosti uloge arhitekture u stvaranju pametnih gradova, te pruža smernice za dalje korake ka razvoju održivih i tehnološki naprednih urbanih sredina.*

Ključne reči: *Pametni gradovi, arhitektura, Srbija*

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1. INTRODUCTION

The role of architecture in creating smart and sustainable cities is becoming increasingly important in modern society, especially in the context of rapid urban development as seen in Serbia. Architecture not only shapes the physical appearance of cities but also plays a crucial role in creating environments that support innovation, sustainability, and a high quality of life for citizens. Through the implementation of advanced technologies, intelligent management systems, energy efficiency, and integration with infrastructure, architecture becomes a fundamental element in transforming cities into smart, functional, and livable spaces. This paper explores how architecture can contribute to the development of smart cities in Serbia, identifying key principles, challenges, and opportunities for enhancing the urban environment in line with the needs of contemporary society.

The development of smart cities is a global trend, and within this topic, there are various works. One segment focuses on the technological frameworks and infrastructure necessary for the functioning of a smart city, such as digital networks and platforms for data collection [1,2]. Other works deal with the human aspect, exploring how smart cities impact citizens and how to involve them in the development process [3]. Additionally, there are studies dedicated to specific smart solutions, such as smart lighting or water resource management [4]. However, in domestic literature, the situation is quite modest. According to the author's knowledge, only two conferences on this topic have been held [5,6] and only a few papers have been written [7–11]. These papers analyze factors influencing the development of smart tourism, the impact of Industry 4.0 on the development of smart cities, the application of technology in creating smart cities, the influence of sustainable green construction on society in smart cities, and the new paradigm of urban development.

Although Serbia hasn't officially declared any "smart cities," this paper analyzes initiatives and projects in major cities that rely on principles of smart solutions. Through comparative analysis with neighboring countries, it explores key architectural principles relevant to smart cities, examines examples from Serbia and the region, identifies best practices, challenges, and future perspectives. After analysis, the paper offers recommendations for enhancing the role of architecture in the development of smart cities in Serbia, considering factors such as policies, education, public-private partnerships, and other relevant aspects.

2. LOCAL EXPERIENCES

According to its developers' presentation, Belgrade Waterfront is one of Serbia's most ambitious urban projects, not only transforming the city's appearance but also laying the groundwork for smart city development in the region. This modern complex stretches along the banks of the Sava River, in downtown Belgrade, aiming to blend high-tech solutions with sustainable urban planning. Through the integration of digital technologies, Belgrade Waterfront

aims to become a hub of innovation and efficient governance, offering residents and visitors a unique experience of living in a smart city.

One of the key elements of smart cities showcased by Belgrade Waterfront is smart infrastructure. Still in its planning phase, it's expected to utilize advanced sensors, energy and water management systems, as well as smart transportation systems to efficiently utilize resources and minimize environmental impact. Additionally, smart systems ensure quick problem detection and resolution, providing residents with a safe and comfortable living environment. Furthermore, Belgrade Waterfront integrates digital platforms enabling citizens to actively participate in shaping their urban environment. Through mobile apps and online platforms, citizens can provide feedback, suggest ideas, and participate in decision-making processes, enhancing transparency and democratizing urban planning.

This project not only transforms Belgrade's appearance but also sets standards for future city development in the region, emphasizing the importance of innovation, sustainability, and citizen participation in the urban planning process. However, the assessment of the blend of modern technology and comfortable living will occur once all promised aspects are realized. Certainly, the idea of smart waste management in collaboration with energy-efficient buildings represents an initial step toward realizing the concept of a smart city. Perić i Maruna [12] view this idea as a relevant example of urban development under authoritarian neoliberalism.

The "Smart Belgrade" platform [13] has been collecting data for several years to propose the installation of smart services in the fields of ecology, municipal services, and transportation. This goal includes the implementation of advanced sensors, smart traffic lights, vehicle and passenger tracking systems, as well as the development of mobile applications providing real-time traffic information. One of the key elements of smart transportation in Belgrade is the use of technology to optimize traffic flow and reduce congestion on roads. Smart traffic lights that adapt to the current traffic situation and a traffic management system that automatically detects problems and suggests alternatives to reduce congestion are just some examples [14].

In addition to Belgrade, Novi Sad also has an initiative for the development of a smart city with a focus on e-government, smart energy, and the digital economy. [15]. Initially, a public bicycle system was implemented, which can be easily rented at various locations using a mobile application [16]. Novi Sad aims to become a city with smart lighting that will enhance the safety and comfort of its citizens while reducing electricity consumption and harmful gas emissions. Introducing LED technology and sensors that control lighting based on pedestrian and traffic presence will contribute to better energy efficiency and reduced public lighting costs. Additionally, promoting energy efficiency in residential buildings will have a positive impact on citizens' household budgets by reducing energy expenses and increasing living comfort.

Although the goal of "Smart Niš" is to enhance resource control and management digitally and to improve the quality of life for citizens, the implementation of the Smart & Safe City project is currently limited to parking

concepts. Sensors have been installed in public parking lots, along with boards displaying available parking spaces [17].

3. SMART CITY IN THE WORLD

Amsterdam, the leading European city for startups, utilizes the Internet of Things (IoT) for efficient traffic and public lighting management. Smart traffic lights equipped with real-time sensors optimize traffic flow, reducing congestion. Smart parking systems guide drivers to available spaces, alleviating stress and congestion. The city boasts the title of "Bicycle City," with a developed network of bike lanes and bike-sharing services, promoting sustainable transportation. Amsterdam is also a leader in promoting electric vehicles, with one of the highest shares globally. The city has a clear goal: achieving zero emissions and fully sustainable energy using renewable sources such as hydroelectric and wind power. Smart energy usage in buildings through energy consumption and heating management systems ensures efficiency and cost reduction. Amsterdam is a hub of innovation and creativity, supporting startups and tech companies to test their ideas for a better future. Additionally, the city encourages citizen participation in decision-making through digital platforms for e-participation, allowing all citizens to express their ideas and opinions. Since 2009, the Smart City Amsterdam Initiative has enabled over 80 projects to improve the city [18].

Singapore has become known for integrating green spaces into urban infrastructure, such as vertical gardens and green roofs, which not only improve air quality but also provide habitats for local flora and fauna. This initiative illustrates how smart urban planning can positively impact the environment and citizens' quality of life. Additionally, Singapore has adopted advanced solutions to facilitate citizens' movement and reduce traffic congestion, including smart traffic lights, sensors, and traffic management systems. Focusing on the development of sustainable public transport is also a priority, enabling citizens to easily access transport schedule information via mobile apps. City-wide sensors collect data on air quality, traffic density, and water usage, which artificial intelligence analyzes to devise plans for sustainable city development. In the housing sector, Singapore has developed innovative smart housing projects equipped with technology that allows citizens to control their homes via mobile apps, including lighting, temperature, and security management [19].

4. SERBIA IN RELATION TO LARGE SMART CITIES

When comparing domestic experiences with well-known examples of smart cities like Amsterdam, Barcelona, and Singapore, several key differences and similarities become apparent. Cities such as Amsterdam, Barcelona, and Singapore have already made strides in implementing smart technologies and innovative solutions in various spheres of urban life, including smart traffic, energy efficiency, digital governance, and sustainable urban mobility. On the other hand, cities in Serbia, such as Belgrade, Novi Sad, and Kragujevac, are still in the early

stages of implementing smart initiatives, with a focus on digitizing services and smart traffic.

Cities like Singapore and Amsterdam have successfully integrated the private sector into the development of smart urban solutions through public-private partnerships and incentives for innovation. Serbia is also moving in this direction, but there is still room for improvement in collaboration between the public and private sectors to accelerate the development of smart cities.

Smart cities like Amsterdam and Barcelona actively involve citizens in decision-making processes and project development through participatory processes. In Serbia, there is awareness of the importance of citizen involvement, but there is still room for improvement in transparency, openness, and citizen participation in urban planning and development processes.

Based on the analysis, Serbia should continue to develop smart cities through the development of a comprehensive smart city strategy covering a wide range of areas, including traffic, energy efficiency, digital governance, sustainability, and citizen participation. Additionally, focus should be on sustainable technologies and innovations that contribute to ecological sustainability, economic development, and improving citizens' quality of life.

In the field of architecture, for the further development of smart cities, the following are suggested in this paper:

- Development of urban plans that promote sustainable and inclusive architecture, focusing on efficient use of space, reducing greenhouse gas emissions, and creating pleasant living environments.
- Integration of smart infrastructure into architectural designs of cities, including solar energy, water recycling, energy-efficient materials, and digital technologies for resource monitoring and management.
- Enhancement of digitization in architectural processes, including the use of Building Information Modeling (BIM) technology for more efficient design, construction, and management of buildings.
- Encouragement of sustainable construction through the use of environmentally friendly materials, passive houses, green roofs, and vertical gardens to reduce ecological footprint and improve the quality of the environment.
- Investment in the revitalization of old industrial zones and abandoned spaces through architectural design that promotes innovation, creativity, and economic development.
- Designing architecture that is resilient to climate change, including adaptive strategies to combat floods, extreme temperatures, and other extreme weather conditions.

Through these measures, architecture can play a key role in creating sustainable, functional, and attractive urban environments in line with the principles of smart cities.

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