Smart Cities: A Multi-Aspect Approach

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***Abstract*— There are varied reasons for cities building but whoever built them had in mind their functionality and the desire of the inhabitants to live comfortably. Nothing is accidental in a city creation. Differences between the present and the distant past are in technology and the city's size. Today, we are trying to overcome the problem of the city's excessive size using modern technology and innovative solutions and by measuring some parameters and needs of citizens. This paper points out that solving the problem is not in building new cities with all the keys of the smartest-known city. Problem-solving should be in the optimization of existing cities to meet the current needs of the inhabitants, but with the possibility of further improvement to meet future needs. In the paper, the authors discussed the challenges in city traffic, smart tourism, city management, waste management, and the application of information technologies in smart cities. As one of the proposals, the authors proposed the even development of the entire territory of a particular country because smaller cities are more suitable for organizing the life and work of the population.**

Keywords: smart cities, ICT, sustainability, city traffic, waste management, sustainability, cyber security

I. Introduction

Aristotle championed that the city and its inhabitants were partners aimed at mutual well-being. Hippocrates was concerned with climate, water, and soil quality impacting life and human health [1]. From this, we can conclude that the idea of the smart city, despite the popularity of this phrase recently, is not new. What is new is simply a technology that makes it possible to make the city more livable. The term *smart city* includes various coinciding meanings. It is an idea – of an environmentally friendly or *green city*, a sustainable city, or a city that implements innovative technical solutions.

Regarding smart cities, United Nations Development Program (UNDP) proposes modern technologies to ensure inclusive and sustainable urban development, considering people, the economy, and the environment [2].

The topic of smart cities is considered the most common from a technical point of view. The focus is usually on specific technical solutions contributing to various areas of life and work. Having smart solutions that save time, energy and money is of immense importance, but also important is that these solutions are integrated into the framework of local development strategies and serve everyone equally [3]. People flock to large cities in most countries worldwide. The reason is that people are looking for opportunities to ensure a better life.

Most definitions formulated by different authors lead to an expanded interpretation of the smart city concept. The diversity of opinions we consider benefits the smart city concept development.

Authors often define a smart city as having good functionality with a perspective on the economy, governance, mobility, and environment. A *sustainable* city composes the activities of independent and conscientious citizens who can make their own decisions. When considering such problems, the question arises: How to make the city *smarter*?

In science and practice, there are no clear and uniform rules for creating smart cities, so we will present our approach to designing smart cities, which includes several aspects, from the idea itself, through the analysis of citizens' needs, to the financing of smart cities.

II. Smart Cities Make Decisions

Smart cities make development decisions based on measuring the actual parameters and needs of the people living there. After that, decisions on services and infrastructure are made based on the analysis of this data. At the same time, one should not strive to copy one successful model to all cities but should consider the capabilities and specific city needs and look for the best solution to meet the needs of citizens.

The bottom line is that the city should develop strategies to be its best version rather than striving to be like, i.e., Barcelona. While there is nothing wrong with learning from other cities about good urban solutions, one should focus on the real possibilities of a particular city. And one of the first steps is providing data to obtain the services created based on the real needs of residents and the city's potential. A good example is the Serbian city of Priboj, once known as the only heavy vehicle producer, which saw an opportunity for its development in progress in tourism. Therefore, the city has taken steps to improve its image by being open to tourists widely.

The opened Priboj datasets contain even data on hiking trails. That is an open invitation for their use. Given the city is located on the border of Serbia, Montenegro, and Bosnia and Herzegovina, in the valley of the Lim River, surrounded by natural beauties, which thus become even more accessible [4].

The city created for its residents and their needs should consider the available data used. The main task is to determine the object of research, for example, cars or people and their needs. In practice, data on the age of citizens by the municipality can help decide where to build children- or

sports grounds, where walks take place, and in which parts of the city it is necessary to design streets in a specific way to respond to the particular needs of citizens. Thus, neighbourhoods with an elderly population most likely do not need playgrounds with sand and slides, but there will be areas for walking. At the same time, this does not mean that this will be the case in ten to fifteen years when the generation of the population in these neighbourhoods will change. It is necessary to build something that meets the current needs of the residents but also to remember the possibility of meeting future needs.

In smart cities, it is possible to plan the movement by time, choose a route, and estimate the ticket cost through applications for public transport. Thus, an open smart city values the time of its residents. Many cities have become part of the Google Transit system, which shows public transport lines on Google Maps. The app makes sense if public transport operates on a schedule. The BusPlus app used in Belgrade (Serbia) allows users to track the positions of buses that will arrive at a particular station. The 5G networks can significantly improve this area [5].

In waste management, one of the features of smart cities is new solutions for waste recycling. One positive example is the work of a Belgrade-based company that has been successfully innovating the recycling process for many years with its smart presses that can collect and use a large amount of open data. Through a custom application, for each recycled can, the user receives points and can win prizes. From the start of its business, the company has used open data for planning locations and monitoring external conditions to set up smart garbage presses in cities and more than thirty festivals. It has participated in a new project that will include smart garbage presses in cities as data collection points about recycling. At the same time, the company offers some of the data as open data [6].

III. Modern Smart Cities

The digitalization of cities is one of the drivers of the sustainable development of any country. For the further development of both the current smart cities and the candidates for the title of smart city, it is necessary to support new projects continuously. Kirsanov, and Čekerevac in their study [7], saw that the authorities are taking decisive steps to digitize cities by trying to involve citizens in the decision-making process and the understanding that the development of smart cities has a positive impact on the national economy.

The modern *smart city concept* is based on the widespread use of ICT, in which the key is the Internet of Things (IoT). That opens new opportunities for collecting and analyzing the data needed to create a more convenient living environment. Such a communication infrastructure will provide easy access to public services and optimize the transport and security system. The IoT will connect all the smart city elements and turn them into a well-coordinated mechanism.

The current legislation in the smart city area is not perfect. The legal problem is that the established rules do not consider the development of systems needed in the current data era. Hence it is necessary to develop fail-safe procedures for data quality control and to amend legal acts to improve the rules of data closure, which will lead to business interest, stimulate investment support, and attract capital to the digitalization of cities. That will contribute to the internal growth of the national economy of countries.

Smart cities need standardized metrics to measure their performance to improve quality of life and sustainability. There is a need to further develop international standards for an integrated approach to sustainable urban development in collaboration with international organizations, for example, to identify and methodology for a set of indicators needed to manage and measure the effectiveness of urban services and quality of life. Standardized metrics will allow smart cities to measure their performance and progress over time and benchmark themselves against other cities.

The role of local governments is critical to the success of turning a city into a smart one. Such a city should be a stable and attractive place to live and work. That can be achieved through the civic activity of its inhabitants. There should be an open and honest dialogue between municipalities and citizens that will show successes and failures and help to draw lessons. The technologies will not work until citizens become competent enough to understand the advantages of a smart city. It is necessary to create working groups under the leadership to attract and include the citizens.

Smart cities are increasingly facing data management and transactions between unreliable parties. The use of blockchain technologies in the design and operation of smart cities is of fundamental importance. Blockchain technologies can solve the problems of transparency and security. Thus, the blockchain can help more effectively riding of problems with clogged streets, transport, the excessive cost of housing services, etc. All medical organizations should become part of digital health. In smart-health care, the protection of patient data and the impossibility of changing them, falsifying them, or using them for criminal purposes is the solution to social, economic, moral, and ethical problems in this area.

The advantages of blockchain make it possible to accelerate the introduction of that technology into areas related to state and municipal administration.

Improving the state and municipal services provision is carried out to improve the citizens' life quality. Therefore, city authorities must ensure that the resident’s needs are met most effectively. That, in turn, will provide municipalities with a successful political career, continuity, and confidence in the future. Digital services allow citizens to directly influence the city services and the work of state bodies. Hence the city must provide access to complete information in real-time. Consequently, new technologies will undoubtedly improve life quality.

A smart city requires a rapid transition to sustainable transport. It is one of the promising areas where the introduction of modern technologies and the development of

innovations can make significant progress. Smart traffic control solutions are reaching the first level to minimize congestion. Cities are beginning to make full-fledged decisions for intersections, considering the public transport advantages. Technical and technological innovations also offer solutions for residents in the form of mobile applications that work with open data and allow them to provide information about traffic situations. Intelligent transport is focused on the integrated regulation of all transport modes to move passengers optimally. Sustainable, safe, interconnected transport systems will improve the efficiency of environmentally friendly transport.

In addition to conventional transportation, electric vehicles have recently reached the first level. Cities are actively building charging stations for these vehicles, offering free parking in case of charging, and public traffic lanes. Electromobility aims to reduce carbon dioxide emissions and strengthen environmental protection. But currently, in many countries, electrification is not as environmentally friendly a solution as expected [8].

Heavy traffic and congestion are now significant problems for many cities, and with increasing population density, traffic problems are growing even more. The main parameters to be followed are the number of vehicles on the road and the direction of traffic at controlled intersections. They are necessary for priority transport problem identification. Despite all the technology, the use of individual passenger vehicles is rare. Passenger vehicles spend a huge of time parked during their lifetime. Therefore, smart cities should strive to improve public transport and more efficient use of vehicles, e.g., vehicle sharing. That would not only reduce traffic congestion but would also have many side effects.

Education and constant encouragement of innovation can promote the engagement of citizens in smart cities. Smart cities support educational programs that prepare graduates with up-to-date knowledge and practical skills to solve modern problems successfully. Studying the experience of the countries considered in the study, it becomes clear that much remains to do for education in smart cities to become reasonable.

Authorities of different smart cities are introducing services and innovations in the tourism sector. The positive effect of smart tourism - the stimulation of tourism will activate related services and local industries, benefit local businesses, and create jobs.

Smart tourism services strengthen and replace existing services in traditional tourist destinations by:

- Reorganizing old routes accessible to people with reduced mobility.
- Developing tourist itineraries adapted to different visitor profiles.
- Digitizing municipal information to provide easy access from mobile devices for citizens.

Our planet is overflowing with waste that pollutes surface and groundwater, soil, and air, which becomes a problem for every country. Cities need innovative technological solutions to facilitate the collection and disposal of municipal waste. They must find ways to improve the efficiency of the waste-management system and increase the responsible access of the population to waste separation. One way is to implement intelligent technologies that allow you to track collection, evaluate data and optimize the entire system. It should be noted that the relationship between citizens and technology is two-way. While citizens' decisions affect the waste management system, the waste management infrastructure surrounding citizens also influences citizens' behaviour.

In the early phase of waste management technologies formation, primary attention is paid to the collection of data on the amount and type of waste, the transmission of these data, and the evaluation of the software and technologies that enable system optimization based on the data analysis.

In smart cities, smart containers reduce logistics and transportation costs. Garbage cans themselves assess the degree of their filling and independently sort household waste, which facilitates the planning of the schedule for garbage collection in the city and allows the city to save on maintenance. Thanks to solar panels, such containers do not consume electricity. In waste management, one of the features of smart cities is new solutions for waste processing and disposal.

It is necessary to turn to smart energy to solve the problems of smart city development, for example, to the smart grid energy system, which will significantly reduce the energy consumption of urban infrastructure. Smart grids are modern power grids that use information, communication networks, and technologies to collect information about energy production and consumption. It increases the efficiency, reliability, economic benefits, and sustainability of electricity production and distribution. To ensure the Smart Grid program, the active participation of the state is necessary. Still, in this area, perhaps, as in nowhere else, it is inevitable to stimulate the development of public-private partnerships [9].

IV. Open-Minded Citizens Create Smart Cities

For cities' successful development in ancient times, citizens were obliged to participate in public life. Modern smart cities imply the same thing – the cooperation of citizens. Citizens often expect services from the city but do not think they should share information about their needs with the city. Smart cities are based on an active dialogue between the city leadership and the population on the formation of smart city policies.

In Serbia, there are rare cases of an active dialogue between the city leaders and citizens. In most cases, the leadership acts at its discretion, and possible corrections result from demonstrations or the influence of violent reactions of interested citizens. A good example of communication between management and the population is the European project CIVITAS MIMOSA for bicycle paths. In it, the city administration of the Italian city of Bologna asked cyclists to actively share traffic data for one month and then built bicycle

routes and parking lots according to the survey findings. It is significant to mention the protection of the privacy of personal data processed in these cases. Particular attention was paid to the safety of the personal data of survey participants. The EU has adopted several regulations on the protection of personal data within the framework that, in the case of Serbia, are in a new Law on the Protection of Personal Data, which came into force in August 2019 [10].

To comply with the General Data Protection Regulation (GDPR) before starting the work, developers of smart city projects and applications should have a list of what personal data they will process. They must inform citizens what data they will collect, why, for how long, with whom to share them, on what legal basis they do so, etc. These rules also prescribe the implementation of appropriate technical and organizational measures in project planning to preserve the integrity of the data. Personal data protection in developing smart cities is one of the main priorities for the successful operation of a particular project or application.

In smart cities, public places are planned in which citizens like to stay. Smart cities should provide public places where citizens will feel comfortable and enjoy living. A group of young people from Belgrade founded the startup Strawberry Energy and implemented one of such ideas in Serbia [11]. They created smart city furniture and successfully placed it in world capitals. These solar benches are designed beautifully and offer citizens a place to charge their phones, free internet access, and the ability to donate their money to charity. The benches have sensors that collect data on local air quality, noise levels, and other information suitable for creating new practical services or applications.

Creating smart cities is a lengthy process, and it is unrealistic to expect cities to change overnight. What has turned out to be a kind of rule of thumb is that gradually first with a smaller number and then with a planned large number of projects, cities are turning into their more reasonable versions. Not all residents use their towns in the same way, so another long-term point in smart urban planning is full respect for all categories of citizens. Technology is a good tool that is becoming increasingly accessible, but it is wrong to think that it is enough to create a large IoT system to make the city smart. The focus should be on creating cities that meet the needs of their residents with affordable technologies. If citizens are involved in creating the city they live in, there is a good chance that they will respect and support it.

V. Smart Cities Creating

The question is not whether smart city solutions can be used but how to integrate them into local development strategies. Also, it must be defined which key stakeholders will be involved and what financial and human resources are needed for the successful implementation of the smart and sustainable urban development strategy.

A truly smart city must have a comprehensive development plan beyond individual sectors. Many aspects must be considered, including good governance, social inclusion, gender equality, sustainable development, and how these issues are interrelated. We need to find a way to connect things and make technology a tool for solving the complex problems of cities, not an end. It is also imperative that citizens are involved in the planning process from the outset and remain engaged throughout the process. Urban development planning should be bottom-up and people-centred, and the traditional top-down approach should not be used [12].

One effective way to make this possible is to create a municipal team consisting of experts in information technology, governance, society, economics, and the environment who can help decision-makers formulate urban development strategies through technologies focusing on the actual needs of residents. Such an integrated approach will ensure that future cities are aligned with the UN Sustainable Development Agenda and contribute to achieving the Sustainable Development Goals [13].

VI. Financing the Development of Smart Cities

Much can be done by optimizing the use of available funds, but the development of smart cities requires additional investment. Cities can provide part of the investment from the collected taxes, and public funding, donations, and preferential EU loans are also available. Ideas and the desire to implement them are very important. Money itself is rarely an insurmountable obstacle.

In Serbia, smart cities are still not given much attention. For example, the newspapers published a big headline for developing smart cities with 206 million dinars. Under the headline, they wrote, "Minister without Portfolio for Innovation and Technological Development Popovich handed over contracts today to representatives of eight local authorities who received funds for projects under the smart city development program totalling just under 2 million euros." The program aims to improve the innovative capacity of cities and municipalities. The minister signed contracts with representatives of Čačak, Kraljevo, Gornji Milanovac, Užice, Arandjelovac, Kikinda, Zaječar, and Belgrade [14].

If you look at what the funds are intended for, you can see that they are planned mainly to increase the safety of citizens. In Kraljevo, a city in central Serbia, there is talk about creating a video surveillance system for punishing traffic violations. The value of the project is around 200 thousand euros. In the city of Čačak, an SOS system is planned for approximately the same amount of money.

On the other hand, a year later, the Serbian president announced that the National Stadium for 55000 spectators would be built in Belgrade and cost 250 million euros. If we compare the investment, we can see that over a hundred times more will be invested in one stadium to make them "smarter" than eight cities received to be safer. All this happened during the COVID-19 pandemic when world football was played in empty stadiums, and everyone expected that such a situation would last for years [15].

The government very timidly announced the "Smart Village" project starting in 2020, which will make available to villagers new technologies to reduce the population outflow from the villages. However, the government did not define the level of investment in this project, so the probability of project realization is extremely low.

VII. Conclusions

People create smart cities to meet the needs of citizens. In our opinion, at this initial stage, too little attention is paid to citizens and too much to technology. Like many authors, we suggest cities actively involve citizens and exchange experiences with leading cities. Smart city implementation projects often target economic benefits. We believe that cities

should pay more attention to sustainability and ecology. They should actively use international partnerships in innovation and ICT for such purposes.

There are many examples of smart cities worldwide. Each has its specifics. The more creatively municipalities approach the problems of smart cities, the more efficiently their programs develop: smart traffic lights, smart lighting, smart parking, energy-efficient buildings, smart mobility, intelligent waste management, etc. So far, the most visible results are in smart parking lots, although the notification that there are no free parking spaces will not make drivers happy.

Of course, this paper did not intend to analyze all the problems and ways of realizing smart cities. We understand that this is still the beginning of creating smart cities and that there are challenges in construction, energy, infrastructure, technology, sustainable mobility, urban safety and cyber security, and innovation ecosystems. What we could propose for the development of smart cities deviates in many ways from contemporary tendencies in the movement of the population. We see that cities are getting bigger every day, but we should strive for more uniform development at the state level. It is easier to form small smart cities than smart megacities. Also, we should strive for sharable resources. For traffic in smart cities, it is much more advantageous to use car-sharing than privately owned cars. Reducing the size of the city also reduces the amount of waste and the need for large landfills. Big cities create their microclimate, which can have a significant impact on climate change, but also on excessive local air pollution. These can be reasons to think about reducing the size of cities. It is not reasonable to achieve this by force, but it is possible to modernize small towns that become better places to live than big cities. The rest would take its natural course.

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