SELECTED ASPECTS OF SMART CITY CONCEPTS: POSITION OF BRATISLAVA

Kristína BACULÁKOVÁ
Faculty of International Relations, University of Economics, Dolnozemská cesta 1, 85235 Bratislava, Slovakia
kristina.baculakova@euba.sk

Abstract
Author discusses the selected aspect of the smart city concepts. It evaluates the position of Bratislava in two indexes - IMD ranking and European Smart Cities benchmark 4.0. It examines the biggest problems, especially transport and air quality. It also identifies the main objectives of the strategy for the future development of urban transport. Although Bratislava is not a smart city yet, its goal is to apply intelligent urban solutions to make public transport more attractive and thus improve the comfort of its citizens. In addition, participation in the new ATELIER project can bring to Bratislava valuable advice from experienced partners, as well as a comprehensive vision of the city's development by 2050.
Keywords: smart city, public transport, air quality, Bratislava.

1. INTRODUCTION

Increasing urbanization is deteriorating the ability of cities to create a favorable environment for their citizens. The population of cities is growing, as well as daily commuting to work places. This increases the pressure on existing infrastructure and brings not only discomfort but also economic losses. The ever-increasing number of cars in cities is contributing to the deterioration of air quality. In addressing these and many other problems, cities are adopting different solutions within smart cities concepts. In the process of creating smart cities, some cities are better, some are making progress only very slowly. Since smart cities are generally associated with the use of ICT, there is also a premise that only larger and wealthy cities are successful in introducing technology. In recent years, however, it has become clear that even smaller cities of post-Soviet countries can create comprehensive concepts for their long-term sustainable development. Latvia (Riga) is also a positive example of this. The concept of smart cities cannot be seen only as a marginal topic. If the city is unable to deal effectively with the demands of urbanization, it will collapse.

In presented paper we start with the literature review on creating the smart city. We evaluate the position of Bratislava within two indexes. The first is the index of the International Institute for Management Development and the second is the European Smart Cities 4.0, developed by the Technical University of Vienna. The position of Bratislava in these indexes is quite different. However,

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

each index indicates the weakest points that are most distant from achieving smart status. Based on the identification of weaknesses in the article below, we analyze the current situation in Bratislava. We pay attention to the measures taken by the City Council of Bratislava and the goals it wants to achieve by these measures. We focus on evaluating two critical areas, transport and air quality. The aim is to point out that targeted and organized (albeit slower) deployment of smart solutions can help the sustainable development of the city and improve the lives of its citizens.

2. LITERATURE REVIEW ON SMART CITIES

The issue of urban growth was addressed in the literature before we encounter the concept of smart city. At the same time, the concept of smart city is somehow just a summary of the theories of urban development. (Caragliu, Del Bo, Nijkamp, 2011). Of course, in the beginning, smart city was considered a city that applied ICT technologies in key areas of its ecosystem (Harrison, Donelly, 2011). SO, J. et. al. (2019) describe smart cities and smart mobility as one of the fourth industrial revolution technologies. There is, however, no single definition on smart city. (Ristvej, Lacinák, Ondrejka, 2020). We also see some alternative to the term smart in the definitions – such as intelligent or digital. (Moura, de Abreu e Silva, 2019).

Many of the approaches are bottom-up and they arise from experience with certain problems. (Dameri, 2017). Therefore, smart city is today related to six main areas – smart economy, smart mobility, smart environment, smart people, smart living and smart governance. (Moura, de Abreu e Silva, 2019). Smart economy is mostly focused on the competitiveness and the ability and flexibility to transform and adapt to changes. Smart mobility refers to sustainable, innovative and safe transport systems. Smart environment protects natural resources. Smart people focus on the human capital and the participation of citizen in public life. Smart living usually contributes to improving the quality of life in the city - from severance housing to culture. Smart governance is mostly connected to transparency. (Giffinger et. al., 2007).

McClellan, Jimenez, Koutitas (2018) define three dimensions of ´smart´ - project, policies and language. It is important to ask questions, if the technologies make the city smart, if the city is energy efficient, automated and environmentally friendly and if the citizens have access to justice, safety, work, education and culture. When implementing smart city strategies, it is also important to take into account funding possibilities. The classic model count with government-level funding (large urban areas) and local and community funding. As technological solutions require higher initial investments, it is necessary to look for other sources of financing, such as PPP loan projects and, in particular, to attract private investors. They have financial resources and are usually more inclined to invest in new technologies and riskier projects.

In the following table, we summarized how the concept is perceived by different authors:

TABLE 1 - DEFINITIONS OF SMART CITY CONCEPT

Definitions (and key words)	*Author*
The application of complex information systems to integrate the operation of urban infrastructure and services such as buildings, transportation, electrical and water distribution, and public safety (ICT, information systems)	Technical companies CISCO, IBM, Siemens
Education, participation, technical infrastructure, various 'soft factors' 6 characteristics model (smart economy, smart mobility, smart environment, smart people, smart living, smart governance)	Giffinger et. al (2007)
Investment in human and social capital to fuel sustainable economic growth (human and social capital, sustainability)	Caragliu et. al. (2011)
The main idea of this approach is to use digital technologies for improving the quality of life. (digital technologies)	Samouylov et. al. (2019)
Smart city is an urban development project or policy (policy)	Vanolo (2013)
Smart city would improve citizens' lives by facilitating the use of different services, such as public transport and support services for living. (improved living of citizens)	Suopajärvi (2018)
Smart city is the multidisciplinary paradigm (multidisciplinary)	Betis et. al. (2018)
Smart City is the urban center of the future, made safe, secure environmentally green, and efficient because all structures - whether for power, water, transportation, etc. are designed, constructed, and maintained making use of…computerized systems	Hall (2000)
Providing happy and healthy communities (happy and healthy)	Guan (2012)
Smart city and smart mobility are one of the fourth industrial revolution technologies (industrial revolution)	So et. al. (2019)
Criticism of smart cities – as the dominance of the entrepreneurial version of smart cities, relying blindly on ICT instead of people (criticism, entrepreneurship)	Hollands (2008)
Smart city explores, experiments with and uses these technologies to improve its community. (community, technologies)	McClellan, Jimenez, Koutitas (2018)

Source: author´s own processing

Despite many definitions of smart city, Kitchin (2014) points out, that the research on creative cities is only in its early stage and conceptual development. It can be said that there is not a single good way to create a smart city. However, the definitions are broadly in line with the involvement of new technologies to improve the quality of life in the city, and that the concept of smart city should be clearly people-centered.

3. THEORIES OF URBAN GROWTH

Smart cities are closely related to urban growth theories. Initial growth of the cities was linked to industrialization. Currently, urban growth has taken another form. First, the urban renewal, second, the urban competition between cities, third the rise of availability of cars and therefore the movement of

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

citizens to suburbs or satellite villages and fourth the evolvement of hierarchy of urban centers. (Harvey, Jowsey, 2004). Basic economic theories explain the existence of urban growth. The economic base theory explains the size of the city through the size of its export of goods and services. This theory is based on the growth of so-called basic activities (towards external environment), which leads to the urban growth. Input-output theory is more complex. It treats the urban area as an open economy and concentrate on the value of its inputs and outputs. There is also a Keynesian model, which focuses on the total income of the urban area. Urban growth is then determined by the size of the money inflow. (Harvey, Jowsey, 2004).

However, none of the theory really explain, why cities grow (or decline). The reason is simple – the is no single factor affecting this. On the other hand, many factors influence the size of the city. These are advantages as well as disadvantages of urbanization:

Advantages include:

- Specialization;
- Large-scale production;
- Complementarity of activities;
- External economies of agglomeration;
- Economies in the use of public services.

Disadvantages include:

- Higher transport costs;
- Traffic congestion;
- Increased pollution;
- Town vs. country dichotomy. (Harvey, Jowsey, 2004).

Due to these factors we can talk about the so-called, optimum size of the cities. There is a point beyond which the city should not expand. Marginal analysis suggests the optimum city size at the point where marginal cost (MC) meet with marginal benefits (MB) (O1). However, at this point, the average benefits are still higher than the average cost (AC), which will affect the growth of the city to the point where average cost will meet the average benefits (AB). This is also the point, beyond which the city should not grow (O2).

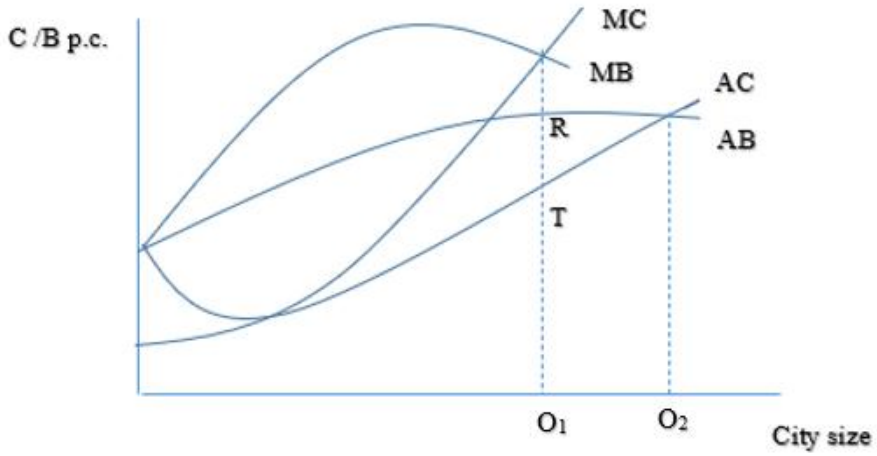

FIGURE 1 – OPTIMUM CITY SIZE
Source: author´s own processing

The theory of the optimal size of the city was already discussed by Tisdell in 1974, at a time when nobody knew anything about the smart city concept. (Tisdell,1974). Harvey and Jowsey argue that there is no single optimum size for the city. This also comes from the concept of urban hierarchy, when there is a so-called central location around which smaller towns (centers) are networking. Each central city performs its own range of functions. The bigger the city, the better the advantage of economies of scale or supply network.

The possible optimum size of the city can be derived from the regional settings such as population distribution, industry production, infrastructure, means of transport, civic amenities and government. Although the size of cities cannot be accurately determined in planning, land use planning is very important. Cities are growing and the problem of land use for profit arises. Population growth in the city puts pressure on housing options, the lack of which pushes prices up. The quality of life of citizens is deteriorating, traffic density is increasing and air quality is changing. The trend of suburbanization also arose with the growing population. With the availability of transport and housing, residents began to move into suburbs. But the development of these suburbs and villages brings another problem, which is commuting to work to the center. In addition, the original intention to move into suburbs for better environmental and life quality often encounters the need to build another roads, motorways, or the construction of additional housing. So lately, a reverse trend has been observed - moving to centers. Smart solutions can cope with the current problems of cities, which are often caused by uncontrolled expansion.

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

4. BRATISLAVA-SMART CITY RANKINGS OF IMD AND TU WIEN

Bratislava is the capital of Slovakia with the population of 432 864 citizens (ŠÚ, SR, 2020) (around 600 000 with its suburbs). However, every day, more than 130 000 people commute every day. This is the results of the analysis of the research of the Bratislava self-governing region, which

worked with the data from SIM cards and their movement during the day and the night. (zive.aktuality.sk, 2019). Of course, there is also a presumption of having two SIM cards, but this is the approximate number of people who come to work in the capital every day but live outside of Bratislava. According to the urban hierarchy theory, Bratislava is not only capital, but the central place with its smaller suburb towns. The increase in population is mainly related to the job opportunities offered by the city. Several strategic industrial plants are located in Bratislava as well as most Share Service Centers (41 ouf of 65) in the country.(SARIO, 2019).

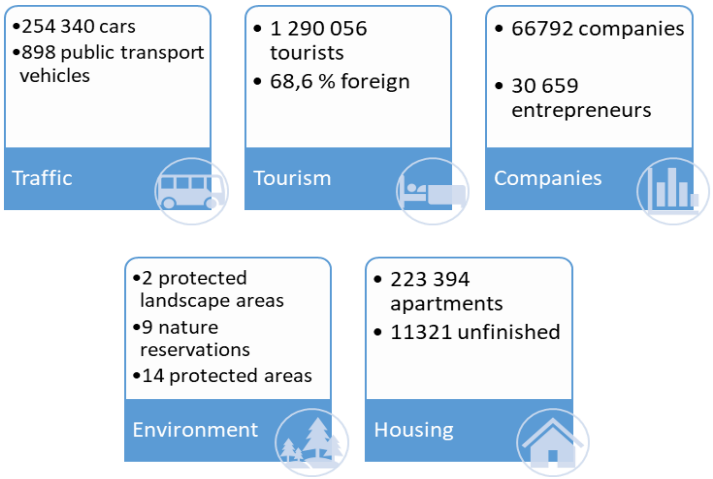

FIGURE 2 - BASIC CHARACTERISTICS OF BRATISLAVA
Source: authors own processing

The rise of the population and commuters causing great problems to Bratislava, namely with the traffic. In the following part, we will look at the position of Bratislava in two smart city indexes.International Institute for Management Development (IMD) has developed smart city ranking. In 2019, Bratislava ranked on the 84th place out of 102 rated cities. It´s overall ranking is CC (structural ranking even worse, CCC1). (IMD,2019). This result is, of course, extremely unsatisfactory for the capital of Slovakia. The ranking consists of five main components – health, mobility, activities, opportunities and governance. Each component reflects several indicators. The most important is to know, what the weakest parts are in order to address them more specifically.

[1] Out of A-D

In the health management, the weakest ranking is reached in the area of air pollution. This is not surprising, since air pollution is closely linked to traffic. Traffic congestions are the weakest part in the mobility component ranking. In the activity's component, green spaces are considered to be very unsatisfactory. On the other hand, the opportunities to work and study are perceived as good and the whole component reached the best evaluation in the complex ranking. The most visible problem in this area is the acceptance and equality of minorities. Except of traffic congestions and air pollution, one of the worst components is governance. Corruption is perceived as one of the weakest points in the city management.

According to public opinion, IMDs identified five biggest problems of Bratislava:

- Traffic congestions;
- Lack of affordable housing;
- Corruption;
- Lack of green spaces;
- Air pollution. (IMD,2019).

Another smart city ranking of Bratislava is provided by Technische Universität Wien. TU Wien has developed the initiative called European Smart Cities 3.0 in 2014. This initiative compares benchmark for the selected European cities (100 000 to 500 000 citizens). In 2015, the initiative was broadened to bigger cities (European Smart Cities 4.0). The ranking consists of a classic model of smart cities, namely:

- Smart economy;
- Smart environment;
- Smart mobility;
- Smart people;
- Smart governance;
- Smart living. (TU, 2015).

Surprisingly, results are different from the IMD ranking. Bratislava ranked quite well at smart city indicators as well as smart mobility. This is totally in contrary to IMD. The research is four years older, however, it was assumed that the indicators are improving in time. On the other hand, the governance and entrepreneurship ranked very poor. Housing or environment also reaches negative values. The

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

average ranking for all components of this index is also in negative values. For the illustration, we picked the comparison of Bratislava and Helsinki. This choice of cities is not random. Helsinki is similar to Bratislava in many basic characteristics, so the two cities are probably the best comparable. The population of Helsinki in 2018 represented 643 272 citizens. Bratislava had a population of 432 864 (ŠÚ, SR, 2020), but with its satellites, the population is rising above 600 000 citizens, which is comparable to Helsinki. The green area of both cities is also comparable, however, Bratislava has only about 2 % of city greenery (parks, gardens, residential greenery). The rest of the greenery is represented by forest areas around the city. The population density of Helsinki is about 2 934 /km2 in the city area, however, if we consider whole Helsinki area, the population density declines to 379 /km2 (the Metropolitan area of Helsinki – Pääkaupunkiseutu consists of four municipalities: Helsinki, Espoo, Vantaa, and Kauniainen). The density of Bratislava is lower, around 1 163,53 /km2. (Baculáková, 2019).

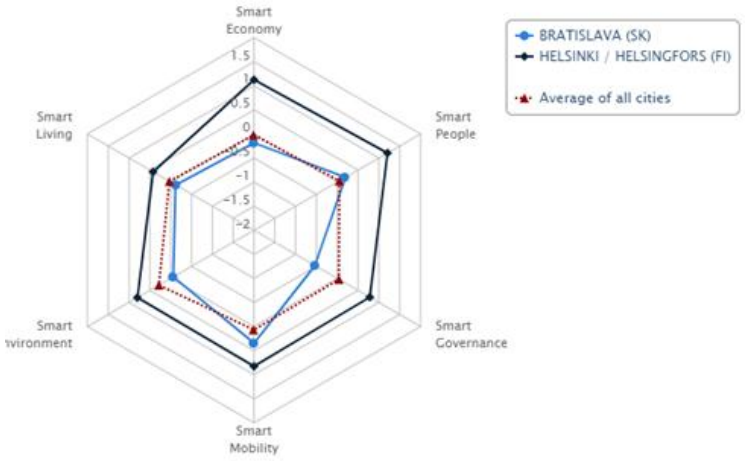

FIGURE 3 – SMART CITY BENCHMARK OF BRATISLAVA/HELSINKI ACCORDING TO TU WIEN
Source: smart-cities.eu

The results of the comparisons in the TU index are significantly in favor of Helsinki. Also, the IMD ranking for Helsinki is very high (8th place). The red line represents the average values of all cities. It is important to highlight components where Bratislava achieves below-average value. These are basically four out of five. The biggest drop compared to the average is recorded by smart governance, other parameters are almost slightly below the average. The question remains, why Bratislava scored generally as badly and how can we learn from such successful places as Helsinki, which can serve as a good example.

Slovakia reacted a little later to the complex concept of smart city. On July 11, 2018, the Slovak government approved a financial mechanism for smart cities. The aim is to introduce funding opportunities and create a motivating environment for such initiatives. As mentioned above, there are two main priorities reflecting the problems perceived as the most crucial – traffic and air pollution. Air pollution in Bratislava area is mostly caused by PM2.5 a PM10 particles. PM2.5 represents fine

particles. These particles are part of the traffic exhaust gases, street dust or results from burning the wood. In addition, these particles are transportable through long distances. PM10 particles arise from street dust, asphalt, tyres and brakes of cars, that means traffic. Traffic congestions in Bratislava concentrate theese particles in the vicinity of busy roads. Activists recently warned that the volume of ultra fine particles in the air exceeded 180,000 particles. (bratislava.sme.sk, 2019). However, already 20,000 particles represents a danger to human health. With the rising amount of particles, also the toxicity of the air rises. Such air poses health risk namely to small children, pregnant women or seniors. Polluted air contributes to the growth of diseases such as asthma, cardiovascular diseases and oncological diseases. (WHO, 2020). In addition, these ultra-fine particles carry more easily alleregesis (like pollen grains), which worsens the health situation of people with allergies and asthma. Activists responded to insufficient measurement of air quality. Accordingly, the Ministry of the Environment plans to build new metering stations. Regional Public Health Office also explains that Bratislava has good scattering conditions and minimum days with inversion, so the concentration of dangerous particles is rapidly decreasing.

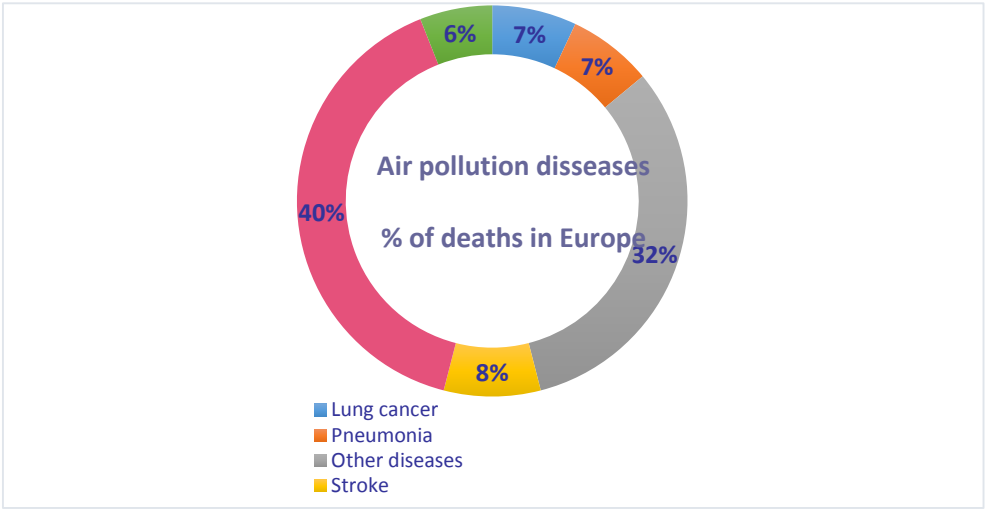

FIGURE 4 – AIR POLLUTION DISSEASES CAUSING DEATHS (% EUROPE)
Source: greencarcongress.com

5. BRATISLAVA-SMART CITY ACTIVITIES OF THE MUNICIPALITY

The Municipality of the capital is trying to deal with the main source of air pollution, and this is transport. In addition, traffic congestions are one of the problems that most troubles the Bratislava citizens, but also commuters. Every working day, in the morning and in the afternoon rush hour, columns are formed that make it much more difficult and lengthy to get to work. The Mucipitality created the study mapping the biggest problems of public transport in the city and proposing solutions and goals that the city wants to achieve in terms of building smart traffic.

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

The main problem (not only) of public transport is congestion. Congestions during peak hours is mainly generated on access radials. City Municipality study states that public transport delays are up to more than 20% compared to timetables. (Bratislava, 2014). Another problematic area is the comfort of traveling. It is often a decisive factor for people, whether to use public transport at all. Among the factors of discomfort can be the loss of time by public transport, comfort and culture of travel, time loss when changing. According to the study, the density of passengers in public transport in Bratislava was 5 people per m2. Yet in other large cities it is up to 4 passengers per m2. Buses account for up to 82% of urban public transport. (Bratislava, 2014).

Several solutions to the key problems have been proposed in the urban transport development plan, mainly:

- preference of public transport in the city;
- analysis of the position of individual stops;
- increasing the efficiency of transport performance;
- preferred lanes;
- -preference for public transport vehicles at traffic lights.

Of course, with the modernization of transport, the question of using electro mobility arise. The question of using electric buses depends on the possibility of charging. At the same time, such buses can be used in the so-called off-peak times or on the side roads. (McClellan, Jimenez, Koutitas, 2018). It is most advantageous to use a vehicle with a long-range battery or vehicles with an auxiliary electric drive. Rail transport should also be strengthened - especially trams. It will be the modernization of existing lines as well as the construction of new ones.

The new concept aims to increase travel speed, comfort and travel culture, increase capacity on congested lines and improve the accuracy and reliability of connections. On the other hand, it aims to reduce emissions, reduce noise and thereby improve the quality of life in areas close to connections (such as trams) or reduce operating costs.

In connection with these objectives, certain technical requirements are also imposed on further operation and modernization. These include, for example, the requirement of covered stops, a special pavement surface in front of the stop, the availability of ticket vending machines or stop information panels, which provide information on the acute movement or delay of individual connections. The preference of public transport links at traffic lights should be ensured by a digital radio network using a specific communication protocol. Optical signaling of vehicle registration at the traffic lights is also under

consideration (for example, smaller white lights could be added at the lights in addition to the classic three-color signaling).

One of the most significant achievements of Bratislava is the involvement in the ATELIER project - Smart cities managed by communities. Bratislava is among the so-called fellow cities that will replicate and adapt successfully implemented solutions and serve as test sites for future smart cities. The project is aimed at developing positive energy areas. Each of the cities must prepare a long-term vision plan by 2050. The consortium consists of the pilot cities of Amsterdam and Bilbao and the cities of Bratislava, Budapest, Copenhagen, Krakow, Matoshnos and Riga (Bratislava.sk, 2019).

6. CONCLUSIONS

In this paper we analyzed the current state of smart solutions in cities, particularly in Bratislava. Smart cities are no longer just about introducing new technologies into the everyday life of a city, but technologies can greatly help make more services in the city more efficient. A typical example is the introduction of new technologies in the public transport system, waste management, energy production and environmental monitoring. An example is Bratislava, which is gradually trying to implement smart solutions in packaging, which appear to be the most problematic. Unfortunately, Bratislava does not score as a smart city. Not yet. The main problems of the city are poor air quality – the air quality is one of the worst in Europe; traffic jams, old, energy-intensive buildings, chaos in urban construction and missing long-term sustainable city development plans. With the participation in the ATELIER project, this should be eliminated. Of course, the most pervasive are the problems that affect the daily life of the city's inhabitants.

The IMD index clearly shows that Bratislava's weakest point is its traffic situation. In the long run, this already appears to be collapsing. And not only in the city. Every day, people from all over the country come to Bratislava to work. Cars in front of the city get into long columns, the city ring road is almost impassable, as well as driveways inside the city. One of the reasons is the absolute preponderance of road transport. There is no metro in Bratislava, and although tram transport is also used, bus and trolleybus connections prevail, both of which are on the road. In addition, commuters prefer passenger car transport. The capacity of Bratislava's roads as well as the motorway is therefore not sufficient.

The deterioration in air quality is also associated with increasing traffic density. Bratislava is ranked among the cities with the worst air quality in Europe, which can be seen through the European Air Quality Index. Most of the toxins are concentrated at large intersections and major urban roads. It is therefore important that the transport problem is resolved as soon as possible. Bratislava has adopted a

Theoretical and Empirical Researches in Urban Management
Volume 15 Issue 3 / August 2020

plan for the development of urban transport, which should help in particular to increase its attractiveness for citizens so that they stop using cars.

Building smart city is not a matter of weeks. Therefore, it is not possible to complete all aspects at once. In addition to transport, Bratislava will also have to address the accessibility of housing to sustainable urban development in the future.

REFERENCES

Betis, G., Cassandras, C.G, Nucci, C.A. (2018). Smart Cities. *Proceedings of the IEEE*. 106. 513-517. 10.1109/JPROC.2018.2812998.

Bratislava.sme.sk (2019). *Výsledky meraní kvality ovzdušia sú alarmujúce, upozorňujú aktivisti.* Accessed: 19.03.2020 from https://bratislava.sme.sk/c/22269018/vysledky-merani-kvality-ovzdusia-v-bratislave-su-alarmujuce-upozornuju-aktivisti.html

Bratislava. (2014). *Koncepcia rozvoja mestskej hromadnej dopravy v Bratislave na roky 2013-2025.* Accessed: 19.03.2020 from https://zastupitelstvo.bratislava.sk/data/att/7003.pdf

Caragliu A., Del Bo C., Nijkamp P. (2011). Smart Cities in Europe. *Journal of Urban Technology,* 18(2), 65-82.

Dameri RP. (2017). *Smart city implementation*. Springer, Heidelberg.

Giffinger R., Fertner C., Kramar H., Kalasek R., Pichler-Milanović N., Meijers E. (2007). *Smart cities ranking of European medium-sized cities.* http://www.smart-cities.eu/download/smart_cities_final_report.pdf

Green Car Congress. (2019). *Study: air pollution causes 800,000 extra deaths a year in Europe and 8.8 million worldwide*. Accessed: 14.03.2020 from https://www.greencarcongress.com/2019/03/20190312-ehj.html

Guan, L. (2012). *Smart Steps to a Battery City.* Government News, 32(2): 24–27

Hall R.E. (2000). The vision of a smart city. In *Proceedings of the 2nd International Life Extension Technology Workshop*, Paris, France, September 28.

Harrison, Donelly. I. (2011). *A Theory of Smart Cities*. Accessed: 16.03.2020 from http://journals.isss.org/index.

Hollands, R.G. (2008). Will the real smart city please stand up? In *City,* 12:3, 303-320, DOI: 10.1080/13604810802479126

SARIO (2019). Shared Services & Business Process Outsourcing Centers in Slovakia. Accessed: 19.03.2020 from https://www.sario.sk/sites/default/files/data/sario-ssc-bpo-centers-in-slovakia-2019-10-15.pdf

Zive.aktuality.sk (2019). Koľko ľudí cestuje denne z Trnavy do Bratislavy Spočítali to pomocou SIM kariet. Accessed: 19.03.2020 from https://zive.aktuality.sk/clanok/140494/kolko-ludi-cestuje-denne-z-trnavy-do-bratislavy-spocitali-to-pomocou-sim-kariet/

Kitchin, R. (2014). Making sense of smart cities: Addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society*. 8. 131-136. 10.1093/cjres/rsu027.

McClellan, J. Jimenez, & G. Koutitas (Eds.) (2018). *Smart Cities: Applications, Technologies, Standards, and Driving Factors* (pp. 209-233). Springer International Publishing. https://doi.org/10.1007/978-3-319-59381-4-13

Moura, Filipe & de Abreu e Silva, Joao. (2019). Smart Cities: Definitions, Evolution of the Concept and Examples of Initiatives. Accessed: 13.03.2020 from 10.1007/978-3-319-71059-4_6-1.php/proceedings55th/article/view/1703/572.

Ristvej, J., Lacinák, M., Ondrejka, R. (2020). On Smart City and Safe City Concepts. *Mobile Networks and Applications.* 10.1007/s11036-020-01524-4.

Samouylov, K., Popov, E., Semyachkov, K. (2019). Institutional Support of a Smart City. *Montenegrin Journal of Economics*. 15. 87-98. 10.14254/1800-5845/2019.15-4.7.

So, J. et.al. (2019). A Study on the Concept of Smart City and Smart City Transport. *Journal of Korean Society of Transportation*. 37. 79-91. 10.7470/jkst.2019.37.1.079.

ŠÚ SR. (2019). *Bratislava v číslach*. Accessed: 13.03.2020 from https://slovak.statistics.sk/PortalTraffic/fileServlet?Dokument=c075f15e-c199-48f2-b959-ad4dbe9f2553

Suopajärvi, T. (2018). From tar city to smart city. *Ethnologia Fennica*. 45. 79-102. 10.23991/ef.v45i0.68961

Tisdell, C. (1975). The Theory of Optimal City-Sizes: Elementary Speculations about Analysis and Policy. *Urban Studies*. 12. 61-70. 10.1080/00420987520080051.

Vanolo, A. 2013. Smartmentality: The Smart City as Disciplinary Strategy. In *Urban Studies* 51(5). pp. 883-898

WHO (2020). *Ambient air pollution: Health impacts.* Accessed: 12.03.2020 from https://www.who.int/airpollution/ambient/health-impacts/en/