# Smart Cities and Sustainability in Central-Eastern Europe

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*SUMMARY*

*Accelerating globalisation is setting economies serious challenges. Rapidly changing conditions (globalisation, industry 4.0, sustainability or pandemics) demand innovative solutions from regions. The way in which regions with different levels of development respond to external shocks can have a major impact on (and increase) existing socio-economic disparities between regions worldwide. Central and Eastern Europe is particularly vulnerable in this respect, as a peripheral region, where the impact of various crises is greater due to less diversified economies and lower income levels. The aim of this study is to examine the territorial differences in Central-Eastern Europe and to analyse the situation of smart cities as a potential alternative in the region. The results show that the region's capitals are in the second half of the European ranking in terms of both smart cities and sustainable development, forming a broadly defined Polish-Czech-Slovak and Hungarian-Romanian-Bulgarian capital cluster. The comparison of the components of the sustainability index revealed that cities in the CEEC region are in a less favourable position in the dimensions measuring mostly "hard" indicators (innovation, industry, infrastructure) than in the components measuring more "soft" elements, and the opinion of the inhabitants is diverse about the cities' sustainable performance.*

*Keywords: smart cities; sustainability; Central-Eastern Europe.*
*Journal of Economic Literature (JEL) codes R11, R12*
*DOI: https://doi.org/10.18096/TMP.2023.02.02*

## INTRODUCTION

Spatial social and economic inequality is a fundamental feature of spatial economics (Nemes Nagy, 1990). No two points in space have identical characteristics because their initial conditions (economic, social, and cultural factors) are different (Benedek & Kurkó, 2011). The degree of difference varies in space and time. In the European Union, the issue of spatial disparities is of particular interest, as economic and social inequalities are a major problem in Europe today (Widuto, 2019). With the enlargements of the EU, disparities between countries and their regions have increased steadily, and since the mid-1980s (with the enlargement of the EU to the South and then to the East), to a significant extent. By the late 2000s, income distribution in Europe was much more unequal than the OECD average (Sánchez Carrera et al., 2021).

The European Commission report, while showing convergence between the different parts of Europe since 2000 due to high levels of regional support, also pointed out that these are growing internal disparities at the level of regions (European Commission, 2022). In 2021, the highest GDP per capita among EU Member States was in Wolfsburg (GER) at NUTS3 level with €172,100, while the lowest was in Silistra (BG) with €4,200, a 40-fold difference (Eurostat, 2023). The development of economies (countries/regions) is affected by shocks that are fundamentally reshaping their development paths. Some of these are in the form of crises (economic, financial, health, natural, etc.), others are leading to major transformations such as industrial revolutions (e.g., Industry 4.0, robotics, automation), which are the result of the emergence of key innovations and which are bringing about significant changes at national and regional level. In today's Europe, the main concern, in addition to widespread regional disparities, is the increasing inflationary pressures, which are particularly

affecting peripheral countries in Central and Eastern Europe (Baba et al., 2023). At the same time, in all areas, the idea of sustainability is becoming increasingly important in the face of growing problems, putting new pressures on regions from an economic, social and environmental point of view.

The aim of the study is to examine the territorial differences and current challenges in Central-Eastern Europe (a peripheral region) and to analyse the situation of smart cities as a potential alternative in the region, focusing on the capital cities (Prague, Bratislava, Warsaw, Bucharest, Sofia). Central and Eastern Europe (CEE) was called for several years as the post-Soviet bloc (Nepala, 2018), although there are many different approaches of the geographical limitations of the region. There is an agreement that the EU member states of the CEE region are the Baltic states (Estonia, Latvia, and Lithuania), the four Visegrad countries (Czech Republic, Slovakia, Hungary, and Poland), Romania, Bulgaria and Slovenia (e.g., Istenic et al., 2014; Gajewska, 2021). Also, we can talk about Central, Eastern and Southeastern Europe, which contains from the EU member states Croatia as well as the above-mentioned ones. Besides them the states of the Western Balkan (Albania, Bosnia & Herzegovina, Kosovo, FYR Macedonia, Montenegro, and Serbia), and some countries of the CIS (Commonwealth of Independent States) countries (Belarus, Moldova, Russian Federation and Ukraine), so a much broader area (IMF, 2016). From these countries, the recent analysis is focusing on six countries from the narrower CEE area and dealing with the capitals of the V4 countries extended with Romania and Bulgaria based on their similar development path and common economic history. So later, the recent study's CEE is covering that six territories.

The main research question of the study was to analyse the theoretical and empirical gap between smart city and sustainable city concept. As among the EU member states, different solutions have emerged in the specific geographical areas, and capital cities are at different levels of development in terms of both smart city strategies and sustainability considerations. Both Northern-Southern and Western-Eastern differences can be identified. In CEE, 4 out of 11 cities do not have a complex smart city strategy and only 3 cities have a sustainability focus (Szendi, 2023). The hypothesis is, that among the capitals of the CEE region's member states, different approaches can be found on the application and use of smart and sustainable city strategies, which are stronger in the V4 area, and relatively weaker by Romania and Bulgaria. However, there is not a significant difference in the application of given SDGs.

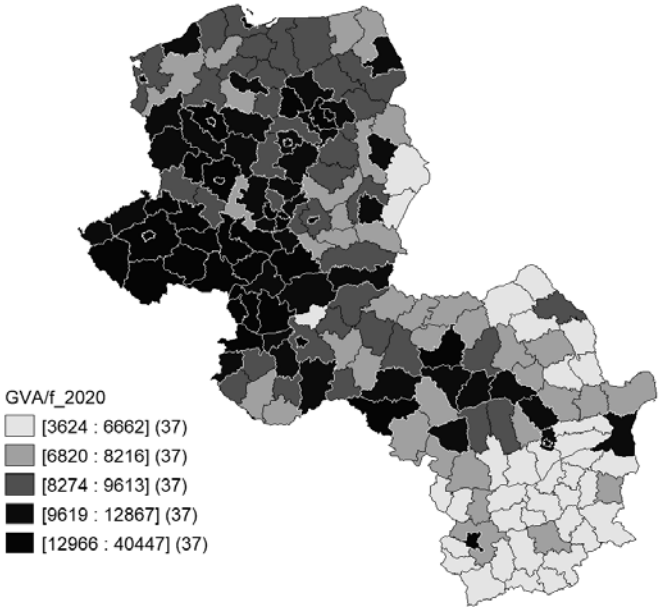
## THEORETICAL BACKGROUND

The study of territorial disparities and catching up is not new. Nowadays, several researchers have analysed the convergence processes of the European regions (Goecke & Hüther, 2016). The question has been whether less favoured/developed regions can grow faster than richer ones and thus catch up. Economic convergence refers to the process whereby relatively poorer countries (or regions) grow faster than relatively richer ones, allowing the former to catch up with the latter (Alcidi et al., 2018). A European Commission study from 2009 looked at the main processes of interregional convergence in the EU. The study found that the process of beta-convergence between EU regions has been achieved in both the EU-15 and EU-27, but that the speed of convergence has not been constant over time. In addition, convergence within some groups of regions was sometimes stronger than in other groups (e.g., centres and peripheries). Sigma convergence suggests a reduction in inequalities between regions over time (Barro & Sala-I-Martin, 1992). The coefficient of variation (CV indicator) of GDP per capita is a widely used measure of sigma convergence. Over the period 1995 to 2019, the value of CV has been roughly halved in both the euro area and the EU27, but the global financial crisis has slowed the rate of convergence significantly in both cases. In contrast, the COVID-19 crisis led to an increase in the indicator in the EU (Licchetta & Mattozzi, 2023), further widening the gap. The authors therefore argue that it is worth looking at changes across several indicators (Widuto, 2019). However, different crises can affect convergence processes to different degrees and in different directions.

According to some researchers, although peripheral regions and countries in the EU tend to grow faster than richer ones, there is more divergence between areas in the long run (Alcidi et al., 2018), and convergence is only meaningful within certain clusters/clubs.

Following the Commission report described above, the European Investment Bank has also examined the impact of the 2008-09 economic and financial crisis on territorial processes. Their analysis shows that regional economic convergence slowed down significantly in 2008-09, after nearly a decade of rapid convergence (European Investment Bank, 2012).

The impact of the COVID-19 pandemics on regional disparities has been analysed by several organisations and researchers. According to the OECD (2020), the COVID-19 crisis has highlighted the widening of regional disparities in economic growth in Europe. Palomino et al. (2020) measured the impact of policies emphasising social distance on poverty and wage inequality in Europe and found that poverty increased, and wage losses occurred during the pandemic.




Source: own calculation and editing based on Eurostat data

*Figure 1: Regional disparities of the GDP per capita in the CEE countries, 2020*

The above Figure 1 shows the disparities of the regional GDP per capita in the Central and Eastern European region for the period 2020. Regional differences within the region are significant and the differences in growth rates suggest that disparities may have widened over the last 15 years. This is supported by the fact that, for example, Hungarian counties had on average lower growth rates than, for example, Slovak or Polish regions. In addition to the existing West-East disparities, the data also show a North-South slope in the country group. Besides some industrial areas, and new areas of excellence (with intensive R&D capacity), the capital cities are the CEEC region's hot spot areas, where the GDP is clustering.

The widening regional disparities and the problems arising from external shocks point out the need for resilience[i]. Resilience is also important for the catching-up of peripheral regions, where the negative impact of various crises can be greater due to a less diversified economy and lower income levels (Sondermann, 2016). So even similar economic shocks can have very different impacts on the performance/competitiveness of more developed and less developed areas (Pénzes et al., 2014). This is why I chose to analyse the processes in the Central and Eastern European region and to explore possible alternatives.

Today, cities are the most important centres of economic activity worldwide (concentration of population, businesses, trade, stock markets). The challenges of the external environment demand new and innovative solutions. At the same time, the sustainable development of cities is emerging as a key policy, which is also challenging them. Smart cities can be the winners in this process, as the smart solutions they deploy can make a major contribution to their resilience and competitiveness. This is why the choice was made to analyse the capital cities of the CEEC region in terms of their smart city performance and sustainability objectives.

The concept of smart cities emerged in the literature in the 1980s and 1990s, primarily as a way of integrating the use of ICT into the everyday functioning of cities. In this period, it was mostly the use of ICT that made cities smart. For example, Hall (2000, p. 1) in his definition stresses the importance of monitoring processes, as a smart city is a "city that can monitor and integrate the status of all its critical infrastructure, better optimise its resources and monitor safety aspects while maximising the services provided to its citizens". Subsequently, soft elements (knowledge, innovation) have been increasingly included in the definitions, but there is still no common conceptual definition. Kourtit and Nijkamp (2012, p. 93), for example, define knowledge and innovation as key elements of smart cities, where "smart cities are the result of knowledge-intensive and creative strategies". In my analysis, I draw on the following definition based on previous analyses.

Smart cities are defined as areas that apply innovative strategies and solutions to improve the quality of life of their inhabitants, while making effective use of their creativity and knowledge base (Szendi, 2019).

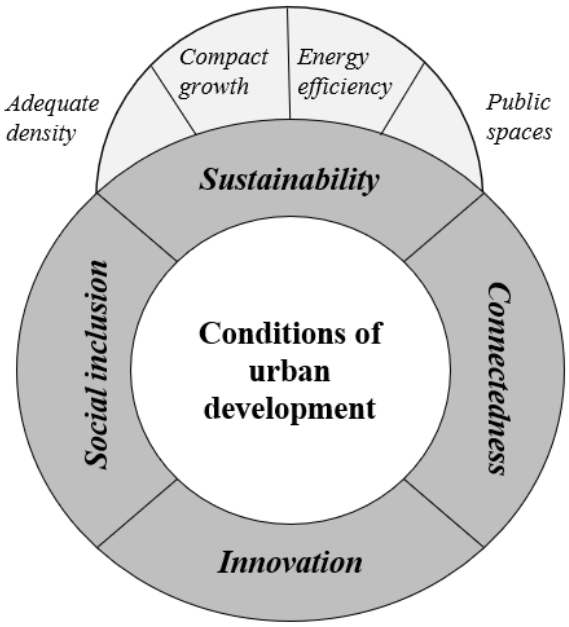
There is no agreed concept in the literature for measuring the performance of smart cities and different ideas have been put forward for the calculation of the component values and the content of the complex index (Nagy et al., 2018). The common feature of these concepts is that they aim to define smart city

performance based on several components and a number of indicators and rely on data from both qualitative and quantitative scales (Szendi et al., 2020).

One of the most used models is the six-component model (economy, people, governance, mobility, environment and living conditions) developed by Giffinger et al. (2007), which measures the performance of cities using 82 indicators of these six dimensions. In Fernandez-Anez et al.'s (2018) smart city model, to adapt to rapidly changing circumstances (resilience), the dimensions are complemented by global trends affecting cities. The main trends affecting cities are interpreted as: climate change, social polarisation, the need for new governance models, global urbanisation, economic instability, and the growing importance of new technologies.

At the same time, the speed and form of responses to changing global trends and shocks may also differ, due to the different governance models of cities. The application of a top-down urban governance model and a bottom-up approach to shocks may not be equally successful, as demonstrated by the response to the impact of the Covid19 epidemic especially in terms of their short- and long-term measurable effectiveness (Szendi & Sárosi-Blága, 2022). In the first period of the pandemics, some cities could improve their position with a bottom-up and co-creation approach, while in the second year of the pandemics, cities that had worked well in the short term with bottom-up management (Amsterdam, Helsinki) has lost ground, while top-down strategies were a more effective way of dealing with the crisis in the longer term (Szendi & Sárosi-Blága, 2022). Duggal (2020) argues that top-down planning should be combined with multi-level, integrated urban governance to respond effectively and flexibly to urban shocks (e.g., pandemics) and to ensure long-term sustainability. A sustainable smart city is therefore a city that, with the support of ICT, meets the needs of its current inhabitants without compromising the ability of other people or future generations to meet their needs, and thus does not exceed environmental limits (Höjer & Wangel, 2014).

According to Barrionuevo et al. (2012), a smart and sustainable city means using all available technologies and resources in a smart and coordinated way to create urban centres that are integrated, liveable and sustainable. Their model can be summarised in the figure below, which in its present form represents a simplification along the sustainability dimension




Source: Barrionuevo et al. 2012, own edition

*Figure 2: Conditions for urban development in terms of sustainability*

Based on this, for the sustainability pillar, it is important to maintain an appropriate population density in cities, i.e., it draws attention to the problems of overpopulation and economies of scale. Compact growth is understood as the integrated treatment of all elements and services, creating synergies and balanced growth. The model also includes the classic energy efficiency dimension, reinforcing the role of renewable energy sources. While in community spaces, the idea of social sustainability and inclusion is mainly present (Barrionuevo et al., 2012).

The concept of economic sustainability is mainly characterised by solutions related to smart economy and smart governance, while socially sustainable solutions are more in the people and living conditions components. Classical environmental sustainability can be found in the environment and mobility pillars.

## METHODOLOGY AND RESULTS

Building on the above, the following section examines the capital cities of the Central and Eastern European region from the perspective of smart and sustainable cities. The analysis will focus about the broader CEEC capitals (Prague, Bratislava, Warsaw, Bucharest, Sofia), which are based on similar starting conditions, historical characteristics, strategic cooperation, and socio-economic characteristics.

In the first step of the study, there was a comparison made for the cities' performance in the smart city rankings and their position among sustainable cities. To analyse the smart city rankings, first the IMD Smart City Index was checked, which was developed in 2017 by two institutions, IMD and the Singapore University of Technology and Design (SUTD). The index focuses on the "human dimensions" (quality of life, environment, inclusion) of smart cities, in addition to their economic and technological aspects. In its definition, a "smart city" is an urban environment that uses technology to enhance the benefits and reduce the drawbacks of urbanisation. The index takes a holistic approach, aiming to explore the different urban dimensions in terms of smart applications (IMD, 2019). The methodology relies primarily on the perceptions of those living and working in the cities under study, while recognising that not all cities start from the same level of development or have the same assets and benefits. The first version was published in 2019, creating the Global Smart Cities Ranking, which has been updated annually since then. Cities are ranked and positioned in clusters (A-D) based on their national HDI value, with an increase in the number of letters (e.g., AAA) indicating a more prominent position within the cluster.

As in previous years, Singapore tops the list for 2021 (Table 1), followed this year by Zurich and Oslo. In Europe as a whole, the Nordic capitals are the best performers, but there are also shifts in their ranking. The capitals of the Central and Eastern European region are mostly in the bottom third of the 118 cities surveyed, as members of cluster C (with a national HDI level around the average). In terms of ranking, the Polish capital is the smartest, followed by Prague only slightly behind. The Slovakian and Hungarian capitals, Bucharest and Sofia form a cluster thanks to their similar positions, lagging the two leading cities in the region by a larger margin (20 and 30 positions for the two groups respectively). Analysing the trends, Budapest has dropped one position in the ranking after 2020, but this is only a change of position, as its results in each year move in line with the corresponding indicator for Bratislava. Another shift in the region is the displacement of Warsaw and Prague, with Warsaw becoming the best CEEC capital by 2021.

*Table 1*

*Ranking of smart and sustainable cities, with a special focus on CEEC capitals*

| | **Ranked by SDG aggregate score (2019)** | **SDG value** | | **IMD Smart City Ranking (2021)** | **Smart city classification** |
|---|---|---|---|---|---|
| 1 | Oslo | 74,8 | 1 | Singapore | AAA |
| 2 | Stockholm | 74,2 | 2 | Zurich | AA |
| 3 | Helsinki | 71,3 | 3 | Oslo | AA |
| | ... | ... | | ... | |
| 26 | Bratislava | 60,2 | 75 | Warsaw | CCC |
| 27 | Prague | 60,1 | 78 | Prague | CCC |
| 31 | Warsaw | 57,8 | 96 | Bratislava | CC |
| 37 | Budapest | 55,4 | 97 | Budapest | CC |
| 38 | Sofia | 55,2 | 106 | Bucharest | C |
| 41 | Bucharest | 54,4 | 107 | Sofia | C |

Source: own editing

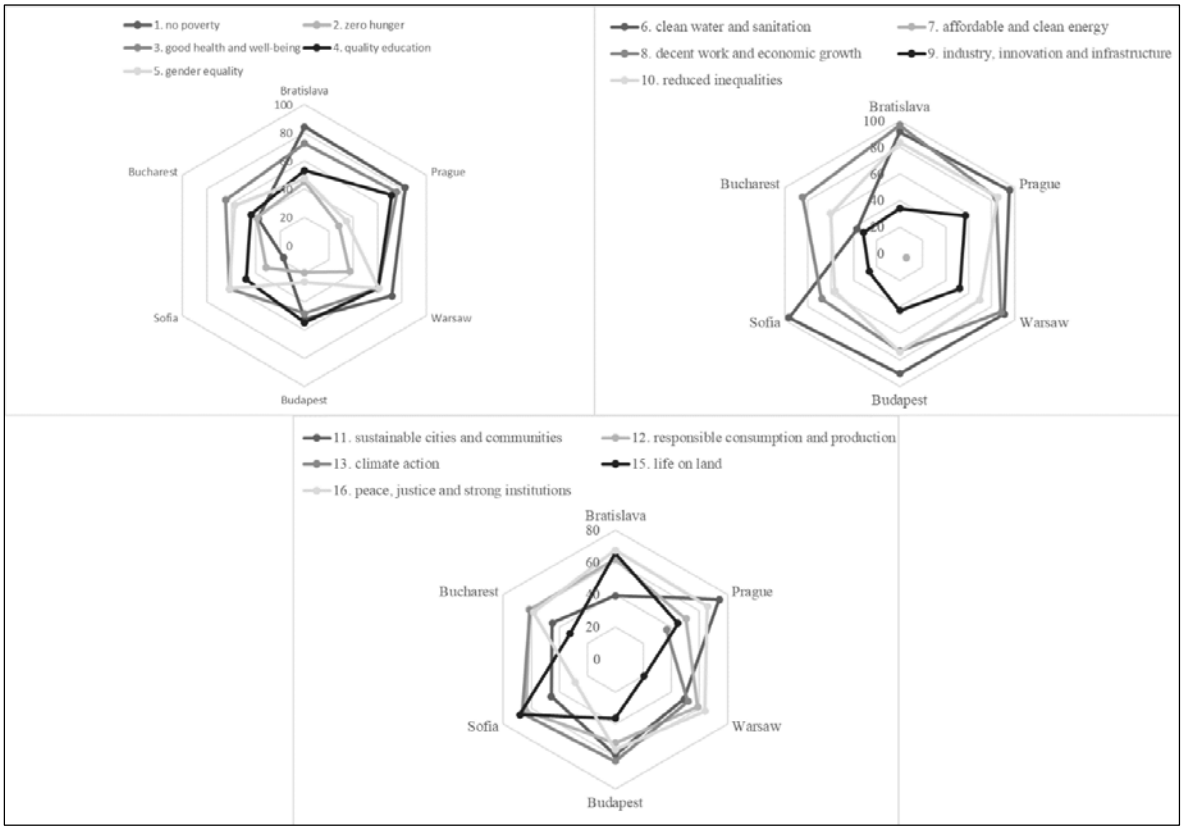
As a continuation of the Millennium Development Goals, the UN adopted the Sustainable Development Goals (SDGs) in 2015, which aim to achieve sustainability by 2030 with a total of 17 targets. The Goals have been adopted by national governments in a global partnership, in line with the UN principles (Lafortune et al., 2019).

The Sustainable Development Solutions Network (SDSN) and the Brabant Center for Sustainable Development (Telos) have produced an SDG index-based benchmarking of European cities, without the less meaningful and data-poor SDG 14 (underwater habitat) and SDG 17 (partnership) targets at the city level, so a total of 15 variables were assessed. The aim of the study was to show that, although national governments have adopted the SDG targets, it is also clear that regions and cities play a crucial role in achieving them (Lafortune et al., 2019). For each target, the level of achievement in the city was assessed and categorised as follows: SDG target achieved (100%); challenges remaining (66-99%); significant challenges remaining (33-65%); significant challenges remaining (0-32%); missing data.

The main finding of the SDG analysis of the European cities is that of the 45 European cities surveyed, three Northern European cities ranked first in the index: Oslo, Stockholm, and Helsinki (Table 1). However, even for these best performing cities, significant challenges remain in achieving the SDGs. The CEEC capitals are in the second half of the 45 cities surveyed, and in this case, they fall into two clusters with similar characteristics. Bratislava, Prague, and Warsaw have similar overall rankings, while Budapest is like the Bulgarian and Romanian capitals. Thus, it can be said that the position of the cities differs slightly from the smart city ranking, although a Polish-Czech-Slovak and a Hungarian-Romanian-Bulgarian cluster can be formed in both cases.

Given the diversity of the SDGs, it is also worth looking at the position of the CEEC capitals at the level of each objective to see which factors are driving the clustering. Due to the number of targets, the position of cities had been checked in three clusters, reviewing 5 to 5 targets in each case.

Looking at the first five targets, Bratislava, and Prague score above average on three and Warsaw on four, with Bratislava scoring particularly high on the poverty (SDG1) and well-being (SDG3) targets. In particular, the Romanian and Bulgarian capitals perform poorly on SDGs 1 and 2 on poverty and hunger, while for Budapest, the gender issue emerges as a problematic component alongside hunger (Figure 3).




Source: based on https://euro-cities.sdgindex.org/#/ own editing

*Figure 3: Position of CEEC capitals along each SDG (2019)*

The second set of targets (SDG6 - SDG10) shows a more balanced picture than before, except for the clean energy component (target 7, data-poor in the region), with larger differences being identified only in the Romanian and Bulgarian cases. The clearly weakest component in the region in this comparison is the industry, innovation, and infrastructure component (SDG9), where only Prague is close to the European average. Bratislava and Prague are also the most prominent in the ranking along three dimensions.

In the last group (SDG11 - SDG13, SDG15 - SDG16), Prague, Warsaw and Budapest have the most balanced performance, with above average scores along all dimensions except for the life on land (SDG15) factor. Responsible Consumption (SDG12) scores very well in almost all regions, while the highest score for SDG11 on Sustainable Cities is in Prague, but the Hungarian capital also scores well.

The analysis of the targets therefore clearly shows that there are significant differences among the CEEC capital cities and that the value/distribution of some dimensions has a significant impact on the overall performance of the cities.

Regarding the positions of the CEEC capitals, it is worth to check whether there is a complex smart or sustainability strategy in the capitals (Table 2).

*Table 2*

*Existence of a complex smart city strategy in the CEEC capitals*

| Country | Capital | Existence of a smart city strategy | Role of sustainability in the strategy | Sustainability is a main objective? |
|---|---|---|---|---|
| Bulgaria | Sofia | no | Smarter-Together project: 2012-2020. There is a Sustainable Energy Action Plan. | no |
| Czech Republic | Prague | yes (2017-2030) | principle of resilience and environmental awareness, but not as exclusive or primary | no |
| Hungary | Budapest | yes | a three-pillar sustainability strategy, integrated into the vision 6 smart components | yes |
| Poland | Warsaw | no | Giffinger et al. (2007) 6 components, not a priority dimension of sustainability | no |
| Romania | Bucharest | no | an evolving strategy, sustainability is not a priority | no |
| Slovakia | Bratislava | no | there is only a climate change adaptation strategy | no |

Source: own edition

Most of the capital cities surveyed do not have a comprehensive smart city strategy, nor is the sustainability dimension a priority. Therefore, also the sustainability aspects from the citizens' perspective was reviewed, starting from the premise that most of the sustainability assessments presented earlier were based on statistical indicators, pollution data, energy consumption and similar data, but that the public's opinion on the improvements achieved and the 'green' status of cities was mostly marginalised. The aim was also to show trends over time, so I checked the status of the data for several years (2012, 2015, 2019).

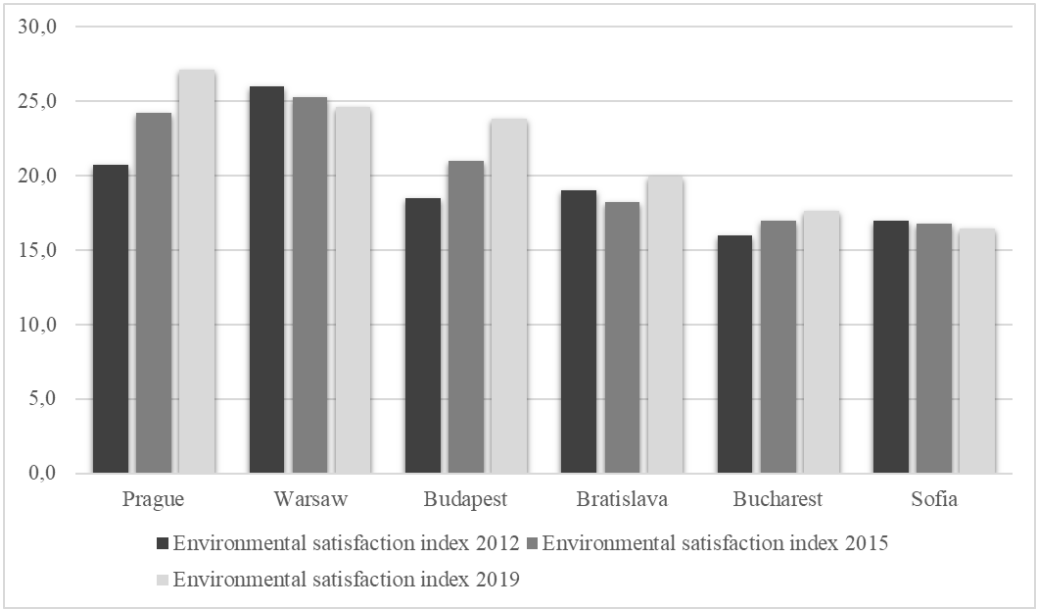
The Eurostat Urban Audit Perception Survey helped me in my analysis. The Urban Audit Perception Survey, which contains a total of 278 indicators measured on a qualitative scale, is a tool for qualitative studies. The survey uses a five-point Likert scale for the indicators, in which respondents can be grouped (1 - very satisfied, 2 - rather satisfied, 3 - rather dissatisfied, 4 - not satisfied, 5 - don't know/no answer). I have reviewed the following indicators:

- satisfaction with urban green spaces (more than 80% of the population very satisfied),

- satisfaction with air quality in the city (more than 80% of the population very satisfied),
- satisfaction with living in the city (more than 80% of the population strongly agree),
- satisfaction with the noise level in the city (more than 80% of the population very satisfied).

Since the scaling and the unit of measurement of the indicators were the same, no further transformation was needed in the calculations. Thus, the complex environmental satisfaction index can be calculated by aggregating and averaging the indicators.

The results of the index in 2019 for capital cities reflect the results seen previously, with capitals in the North and cities with relatively smaller populations performing well, while global cities with large populations, cities in the South and Central and Eastern Europe also top the satisfaction rankings. The Figure 4. below shows cities in the CEEC region.




Source: own editing

*Figure 4. CEEC region capitals based on the Complex Environmental Satisfaction Index (2012, 2015, 2019)*

An overview of the rankings shows that Prague was the leader in 2019, which position was new for the city, as in 2012 and 2015 Warsaw had a clear advantage among the capitals of CEEC, but after that a rapid increase happened in the Czech capital, presumably as an effect of developments, and now both in GDP and environmental term, the Czech capital is the best of the broader region. Almost all the capitals have improved their position from 2012 (except for Sofia, and Warsaw), but its extent was different. The biggest improvements happened in Budapest and Prague, the two cities with complex smart city strategy

## SUMMARY

Accelerating globalisation and the growing importance of socio-economic shocks pose significant challenges for individual economies. Given their socio-economic parameters, the resilience and adaptability of each region will vary. Some regions are better able to cope with these processes, others less so. The study had sought to answer the question of the challenges that the various shocks pose to the Central and Eastern European region and the possible solutions.

The results show that the capitals of the region are in the second half of the European list in terms of smart city ranking and in terms of meeting sustainability targets, and the position of the capitals differs slightly on the two dimensions, but a Polish-Czech-Slovak and a Hungarian-Romanian-Bulgarian cluster can be formed in both cases. The comparison of the sustainability index components revealed that cities in the CEEC region are in a less favourable position in the dimensions measuring mostly hard indicators (innovation, industry, infrastructure) than in the components measuring more soft elements. Most of the capital cities of the area do not have a comprehensive smart city strategy, nor is the sustainability dimension a priority. Based on the opinion of the inhabitants, the Czech capital is the best performer followed by Warsaw and Budapest in 2019, however it is also clear that the biggest improvements in environmental satisfaction happened in Budapest and Prague, the two cities with complex smart city strategy. So, turning back to the initial hypothesis, the difference in the application of smart and sustainable city strategies

is not as clear as indicated, rather only the Czech Republic and Hungary has clear approaches. The second part of the hypothesis suppose that there is not a significant difference in the application of given SDGs, it is true. Only some of them shows great diversity. However, it is worth to mention, that in the future also the other geographical areas should be checked based on these components to see the European disparities better both in smart city strategies and the priority of sustainability. The conclusions can further highlight the success factors of some cities.

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[i] "resilience is the ability of systems, entities, communities or individuals to adapt successfully to changing external conditions and to withstand shocks from outside while maintaining the functionality of subsystems" (Santos & Leitmann, 2016, p. 12).