Comparative Economic Research. Central and Eastern Europe
Volume 26, Number 3, 2023
https://doi.org/10.18778/1508-2008.26.21

Smart Cities for the Sustainable Development of Local Communities: the Cases of the Volyn Region and the City of Lublin

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Abstract

The concept of a "smart city" is being actively implemented by several European cities to improve citizens' quality of life and sustainability at the local community level. The article evaluates "smart city" programs adopted by Ukraine cities in the Volyn region based on well-being assessment. To do so, a literature review was conducted to identify indicators to assess well-being at the local level, and *Benessere equo e sostenibile dei territori* (BESdT, Equitable, and Sustainable Territorial Well-being) was adopted. BESdT is an institutional measurement framework developed by the Italian National Institute of Statistics (ISTAT) to measure well-being at the local level through a collection of indicators that cover different well-being domains. The BESdT indicators available for Ukraine and Poland were collected and then measured. The main goals of the scientific

Received: 12.09.2022. Verified: 13.02.2023. Accepted: 10.06.2023

research are to clarify if it is possible to use the BESdT indicators, which are used to assess smart cities in Southern Europe, for the countries of North-Eastern Europe using the example of the Volyn region and the city of Lublin. The work investigates the indicators of smart cities and considers examples of their construction for 2003–2021. The results testify to the upward trend in implementing "smart city" programs in the regional context. In the Volyn region, the priority areas of project implementation are security, transport, and electricity. In this region, development can be identified concerning trends such as a reduced death rate, an improved balance between work and personal life, increased economic prosperity, and the improved environmental component and security of society. On the other hand, a reduction in innovation implementation and a loss of trust in the government were also identified. The analysis shows that the positive changes above are due to the actions of the central rather than the regional government. Based on the analysis, it was established that the countries of North-Eastern Europe have the level of development of Smart City 3.0, except for Ukraine, which has generation 1.0, and in Southern Europe, generation 4.0.

Keywords: smart city, local community, sustainable development, *Benessere equo e sostenibile dei Territori* (BESdT), city budget

JEL: O18, R11

Introduction

Spatial development is based on the principles of balance and sustainability. Research on the problems of sustainable development of settlements, especially cities, is at the core of Sustainable Development Goal 11 (SDG 11) of the UN's Agenda 2030. The philosophy of sustainable development reflects a comprehensive concept of human development, forming new strategic priorities for socio-economic development. The sustainable development of spatial systems, as a form of organization and ensuring high-quality human life, has given the impulse to change approaches and strategies in the development of states, regions, cities, and local communities. The principles set out in "The transformative power of cities for the common good" (The New Leipzig Charter 2020), "Europe 2020 Smart, Sustainable and Inclusive Growth Strategy" (European Commission 2010), and UN Agenda 2030, illustrate approaches to sustainable development in micro-, meso-, macro and mega levels. The conceptual foundations of the city's sustainable development management are based on the guiding principles and regulatory documents of the European Union (EU), namely the Charter of the Congress of Local and Regional Authorities of Europe (Strasbourg 1957), the European Charter for Regional Spatial Planning (Torremolin Charter 1983), the European Charter for Local Government (Strasbourg 1985), the Gothenburg Strategy for Sustainable Development of Europe (Gothenburg 2001), the Leipzig Charter on Sustainable Urban Development (Leipzig 2007), and the Europe 2020 Strategy "Strategy for Smart, Sustainable and Comprehensive Growth" (Brussels 2010).

A characteristic feature of the sustainable development of the city is complexity and interdisciplinarity. The contribution of experts in the development of the concept of sustainable development at the urban level is to develop research that has evolved into separate sectors of knowledge: ecology, the economics of nature, regional economics, spatial economics, innovation economics, social economics, geography, geoeconomics, urban development, and planning. A synergetic approach to studying sustainable development management of city problems makes it possible to identify inter-environmental integration regularities of the self-organization of urban development as a complex socio-economic and ecological system.

The main goals of the scientific research are: 1) establishing the main BESdT indicators to assess the well-being of smart cities; 2) comparing the indicators of Southern Europe on the example of Italy, and North-Eastern Europe on the example of Poland and Ukraine; 3) establishing patterns of smart city development in North-Eastern Europe on the example of the city of Lublin and the cities of the Volyn region. This article studies the BESdT indicators of smart cities for 2003–2021. Specific cases of the development of smart cities of the Volyn region and the city of Lublin were considered for 2018–2021.

Materials and methods

The term "smart city" is a fuzzy concept (Albino, Berardi, and Dangelico 2015, pp. 3–21). Some scholars use it to refer to the implementation of modern technologies at the urban level, e.g., to improve urban traffic and the mobility of inhabitants. However, many who specialize in sustainability research also highlight other important components (see Albino, Berardi, and Dangelico 2015 for a review of the key dimensions of smart cities). According to Mahizhnan (1999), components of developing a "smart city" include IT education, IT infrastructure, IT economy, and quality of life. Most researchers believe that the development of a smart city is determined by human (e.g., qualified labor), infrastructural (e.g., high-tech communications), social (e.g., intensive and open networking) and entrepreneurial (e.g., creative and risky entrepreneurial activity) capital (Kourtit, Nijkamp, and Arribas 2012, pp. 229–246).

Barrionuevo, Berrone, and Ricart (2012, pp. 50–57) offer five types of capital, including economic (GDP, international operations, foreign investment), social (traditions, habits, religion, family), human (talent, innovation, creativity, education), environmental (energy policy, waste and water management, landscape), and institutional (public activity, administrative government, elections). A smart city should be assessed by the quality of life, the level of sustainable economic development, the management of natural resources through inclusion policies, and the ability to achieve economic, social, and environmental goals (Thuzar 2011, pp. 96–100). It is also influenced by the city's economic

and socio-political issues, the economic-techno-social issues of the environment, foreign economic relationships, the use of appropriate tools, international integration, the availability of development programs, and innovation (Nam and Pardo 2011, pp. 282–291). According to Caragliu, Del Bo, and Nijkamp (2011, pp. 65–82), a smart city cannot operate effectively without the following:

1) the use of network infrastructure to increase economic and political efficiency and ensure social, cultural, and urban development; considering the development of urban business; the social integration of different segments of the population through the use of government services;
2) the crucial role of high-tech and creative industries in the long-term urban development strategy; the important role of social and relational capital in the urban development system;
3) social and environmental sustainability as the main strategic component of smart cities.

Several methods and measurement indicators have been developed to assess the smartness of a city (Albino, Berardi, and Dangelico 2015, pp. 3–21).

According to Caragliu, Del Bo, and Nijkamp (2011, pp. 65–82), it is important to develop a measurement system that should include the following seven levels:

- Level 0: Urban component.
- Level 1: Green component.
- Level 2: Component of the relationship.
- Level 3: Component of tools.
- Level 4: Open integration component.
- Level 5: Software component.
- Level 6: Innovative component.

As smartness is a multidimensional concept that deals with sustainability and quality of life at the local level (Huovila, Bosch, and Airaksinen 2019, pp. 141–153), to measure it, we reviewed methods and frameworks proposed in the literature to measure well-being at the local level. We focus on Equitable and Sustainable Well-being (*Benessere Equo e Sostenibile* – BES), a project to measure the quality of life started in 2010 by the Italian Statistics National Institute (ISTAT) and the National Council of Economy and Labour (CNEL). Based on a participatory and inclusive design process, academics, institutions, associations, and citizens developed a well-being framework and an attendant dashboard of indicators (ISTAT 2013). The framework in-

cludes 130 indicators clustered in 12 domains: Health, Education and training, Work and work-life balance, Economic prosperity, Social relationships, Politics and institutions, Security, Subjective well-being, Landscape and cultural heritage, Environment, Innovation, Research and Creativity, and Quality of services (ISTAT 2019). As discussed in Bellantuono et al. (2021, pp. 50–57), alongside assessment at the national level, ISTAT launched a project to measure equitable and sustainable well-being at the province scale, metropolitan areas, and cities (Calcagnini and Perugini 2019, pp. 149–177). In particular, *Benessere Equo e Sostenibile dei Territori* (BESdT) is configured as the BES framework application at a provincial (NUTS3) scale: the BESdT dashboard consists of 61 indicators clustered in 11 domains (the same as BES, but with Subjective Well-being excluded because of the lack of data at the local level). The BESdT indicators (or a subset of indicators) have been adopted to measure well-being in Italy (e.g., Bellantuono et al. 2021, pp. 1576) and other European countries (e.g., Battis-Schinker et al. 2021; Lazar and Litan 2021, pp. 1009–1028).

Expert assessment methods are used to evaluate smart cities (Lombardi et al. 2012, pp. 137–149; Polinkevych 2016a, pp. 421–429; 2016b, pp. 186–190; 2016c, pp. 126–133; 2016d, pp. 191–197; Antoniuk, Koshova 2021), ratings (Giffender et al. 2007), ensuring the local welfare of cities (Fry et al. 2017, pp. 68–76). It is possible to increase the development of local communities through clustering at the regional level (Polinkevych 2014, pp. 254–257), risk management in periods of crises and pandemics (Polinkevych et al. 2021a, pp. 83–98; 2021b, pp. 99–110), regional sustainable development in the EU and Ukraine (Christopherson, Michie, and Tyler 2010, pp. 3–10; Buzko et al. 2019). The effective development of innovation activity at the enterprise level is impossible without increasing state regulation and applying the experience of developed European countries in implementing innovative models of economic development (Polinkevych and Kamiński 2018, pp. 33–40; Trynchuk et al. 2019, pp. 449–461; Glonti et al. 2020, pp. 169–182; Kuzmak, Kuzmak, and Pohrishchuk 2021).

The article aims to evaluate "smart city" programs adopted by Ukraine cities in the Volyn region based on well-being assessment.

The research methodology is based on a literature review, a survey, and a qualitative case study. Scientific publications from the scientometric database were analyzed for the period 2014–2020, reflecting aspects of sustainable development of territorial communities and smart cities. This allowed us to identify specific features of regional development for the Volyn region.

For advanced analysis, we used a case study (reported in Section 4.1), which revealed the features of the development program of smart cities in the cities of Lutsk, Kovel, Kamin-Kashirsky, and Volodymyr-Volynsky. The BESdT indicators, which were adapted for Ukraine, were used to assess the peculiarities of the development of Ukraine in the Volyn

region. The paper adopts methods of generalization and comparison to determine the level of urbanization of the population in the EU and Ukraine. It compares the BESdT indicators and delineates the general place of the region in socio-economic development.

Results

Data analysis

Today Ukraine is a highly urbanized country, with the level of urbanization increasing to 69.6% in 2021 compared to 66.9% in 1989. Urbanization is higher in the EU than in Ukraine, as evidenced by the data in Figure 1.

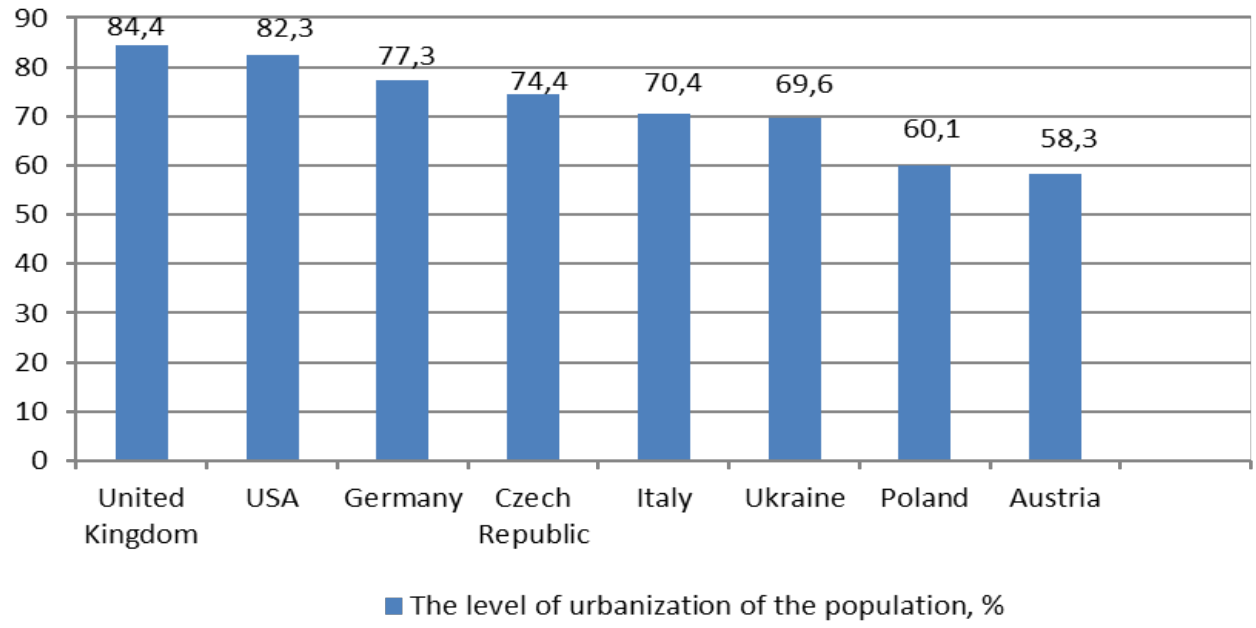

Figure 1. Level of urbanization in the EU and Ukraine in 2021, %

Source: Diia Business. Trade Whit Ukraind n.d.

The Volyn region has a clear European orientation. In comparison, Austria and Poland have less urbanization, at 58.3% and 60.1%, respectively; Italy has 70.4%, the USA – 82.3%, Great Britain – 84.4%, Germany – 77.3%, and the Czech Republic – 74.4%.

Geographically, Ukraine is the largest country in Central-Eastern Europe. However, some researchers do not consider it a country of the Central-Eastern region (Central and Eastern Europe n.d.). The United Nations Group of Experts on Geographical Names (UNGEGN n.d.) listed the following countries as belonging to East-Central and South-Eastern Europe: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Georgia, Greece, Hungary, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia, Europe Turkey and Ukraine (UNGEGN n.d.). Plochii believes that the "New Eastern Europe" should include Ukraine, Belarus,

Moldova, the Baltic countries (according to the CIA World Factbook), and the Caucasus countries (according to the EU Eastern Partnership Program) (Plokhiy 2011). We consider Ukraine to be Eastern Europe, and the level of urbanization in Ukraine does not differ significantly from other countries in Central and Eastern Europe. However, due to the Russian invasion and the aftermath of the COVID–19 pandemic, there are disparities in the development of the regions of Ukraine.

Politicians, at both the national and local levels, need to use BESdT to assess well-being in different areas to better calibrate and monitor the impact of their policies. They should also encourage and facilitate the establishment of subdivisions (working as welfare observatories) in public administration, especially at the regional level, dedicated to identifying specific indicators for the most unstable territories, and measuring and analyzing such indicators over time. Knowledge is required to develop data-focused policies.

Table 1 shows the main BESdT indicators as reported by Bellantuono et al. (2021). However, most BESdT indicators cannot be used in Ukraine due to a lack of data in the State Statistics Service of Ukraine (SSSU) and other institutions. Data can be obtained only for 15 indicators (infant mortality), the employment rate (ages 20–64), paid working days per year (employees), average income per capita, average annual income per employee, capital per capita, non-profit organizations, life expectancy at birth, provincial administrations (collection capacity, losses from municipal water supply, energy from renewable sources, soil sealing, patenting propensity, children who have benefited from municipal childcare services, seats-km offered by local public transport). To consider the full range of indicators, additional statistical surveys would be needed. Accordingly, it is proposed to use the following classes of indicators in Ukraine:

- Class 1. Health, education and teaching: mortality of children under 1 year of age (per 1.000 live births), number of graduates from vocational and higher education institutions.
- Class 2. Balance between work and personal life: the level of the employed population of working age as a % of the population of the corresponding age group.
- Class 3. Economic prosperity: GDP per capita, at current prices, UAH million.
- Class 4. Ecology and safety: the amount of disposed waste.
- Class 5. Innovation and quality of services: share of the amount of sold innovative products (goods, services) in the total amount of implemented products (goods, services) of industrial enterprises, %.
- Class 6. Politics and elections: the level of turnout in local elections.

Table 1. Main BESdT indicators in 2021

Indicator	Measurement	Data are available on the SSSU website (Y = Yes/N = No) (Ukraine)	Data are available on the GUS website (Y = Yes/N = No) (Poland)
Domain 1 – Health			
Life expectancy at birth	Average number of years	Y	Y
Infant mortality	Cases per 1000 live births	Y	Y
Road Traffic Accident Deaths (age 15–34)	Cases per 10.000 residents	N	Y
Mortality due to tumor (age 20–64)	Cases per 10.000 residents	N	Y
Mortality due to dementia and nervous system diseases (65+)	Cases per 10.000 residents	N	N
Number of indicators	5	2	4
Domain 2 – Education and training			
Persons with at least a diploma (age 25–64)	Percentages	N	Y
Graduates and other tertiary titles (25–39 anni)	Percentages	N	N (generally without outlining the years)
Transition to University	Percentages	N	Y
Neet (young people who are not in education, employment or training)	Percentages	N	Y (15–29 years)
Participation in lifelong learning	Percentages	N	Y
Literacy skills of students	Percentages	N	Y
Numeracy skills of students	Percentages	N	Y
Number of indicators	7	0	6
Domain 3 – Work and work-life balance			
Employment rate (age 20–64)	Percentages	Y	N (15–89 years)
Rate of non-participation in work	Percentages	N	Y
Rate of fatal accidents and permanent disability	Cases per 10.000 workers	N	Y
Rate of youth employment (age 15–29)	Percentages	N	N
Rate of youth non-participation in work (age 15–29)	Percentages	N	Y
Paid working days per year (employees)	Percentages	Y	Y

Indicator	Measurement	Data are available on the SSSU website (Y = Yes/N = No) (Ukraine)	Data are available on the GUS website (Y = Yes/N = No) (Poland)
Number of indicators	6	2	4
Domain 4 – Economic prosperity			
Average income per head	Euro	Y (UAH)	Y
Average annual income per employee	Euro	Y (UAH)	Y
Average annual pension income per capita	Euro	N	Y
Pensioners with low pension	Percentages	N	Y
Capital per capita	Euro	Y (UAH)	Y
Rate of bank loans non-performing entries to households	Percentages	N	Y
Number of indicators	6	3	6
Domain 5 – Social relationships			
Average annual pension income per capita	euros	N	Y
Non-profit organizations	Organizations per 10.000 residents	Y	Y
Accessible Schools	Percentages	N	Y
Number of indicators	3	1	3
Domain 6 – Politics and institutions			
Voter turnout (European Elections)	Percentages	N	Y
Voter turnout (Regional Elections)	Percentages	N	Y
Female city managers	Percentages	N	Y
Under 40 city managers	Percentages	N	N
Detention centers crowding	Percentages	N	Y
Municipalities: collection capacity	Percentages	N	N
Provincial Administrations: collection capacity	Percentages	Y	Y
Number of indicators	7	1	5
Domain 7 – Security			
Murders	Cases per 100.000 residents	N	Y

Indicator	Measurement	Data are available on the SSSU website (Y = Yes/N = No) (Ukraine)	Data are available on the GUS website (Y = Yes/N = No) (Poland)
Other reported violent crimes	Cases per 100.000 residents	N	Y
Reported widespread crimes	Cases per 100.000 residents	N	Y
Road mortality in suburban areas	Percentages	N	Y
Number of indicators	4	0	4
Domain 8 – Landscape and cultural heritage			
Density and Relevance of Museums Heritage	Standardized rate per 100 km^2	N	Y
Diffusion of tourist farmhouses	Standardized rate per 100 km^2	N	Y
Density of historic gardens	Standardized rate per 100 m^2	N	Y
Number of indicators	3	0	3
Domain 9 – Environment			
Losses from municipal water supply	Percentages	Y	Y
Disposal of municipal waste to landfill	Percentages	N	Y
Urban air quality – PM10	Percentages	N	Y
Urban air quality – Nitrogen Dioxide	Percentages	N	Y
Urban green spaces	m^2 per resident	N	Y
Energy from renewable sources	Percentages	N	Y
Separate collection of municipal waste	Percentages	N	Y
Soil sealing	Percentages	Y	Y
Number of indicators	8	3	8
Domain 10 – Innovation, research and creativity			
Patenting propensity	Patents per 1,000,000 residents	Y	Y
Employees in cultural companies	Employees per 1000 graduate residents	N	Y
Mobility of young Italian graduates (age 25–39)	Percentages	N	N (20–29 years)
Number of indicators	3	1	2
Domain 11 – Quality of services			
Children who have benefited from municipal childcare services	Percentages	Y	Y

Indicator	Measurement	Data are available on the SSSU website (Y = Yes/N = No) (Ukraine)	Data are available on the GUS website (Y = Yes/N = No) (Poland)
Irregularities in electricity supply	Average number of irregularities per user	N	Y
Seats-km offered by local public transport	Seats-km per resident	Y	Y
Hospital emigration to another region	Percentages	N	N
Number of indicators	4	2	3
Total	56	15	48

Source: Bellantuono et al. 2021.

In the rest of the section, we first present information on the Volyn Region and Lublin, and then we identify and measure the available BESdT indicators for the region.

Volyn case study

Based on the socio-economic development of Ukrainian regions, Volyn ranked 19th out of 24 in 2021, while the city of Kyiv was 17th (in 2020), indicating a weak position in socio-economic development. Based on the level of investment and foreign economic activity, Volyn ranks 25th; it is 24th in the labor market, 20th in the consumer market, and 19th in terms of economic development. Accordingly, Volyn is an outsider in the development of these indicators (Figure 2).

The Volyn region is a western region of Ukraine characterized by the following:

1. It does not have a stable tradition of open political processes due to historical preconditions;
2. Any positive changes in the region are not due to its internal self-development but to the actions of the central government;
3. Centralism, which stands in the way of the authorities forming public policy, is no less concerning to political organizations;
4. Public organizations and business structures are ineffective. Their leaders consider them primarily tools to satisfy personal interests rather than self-sufficient structures that can positively influence the political system of the country.

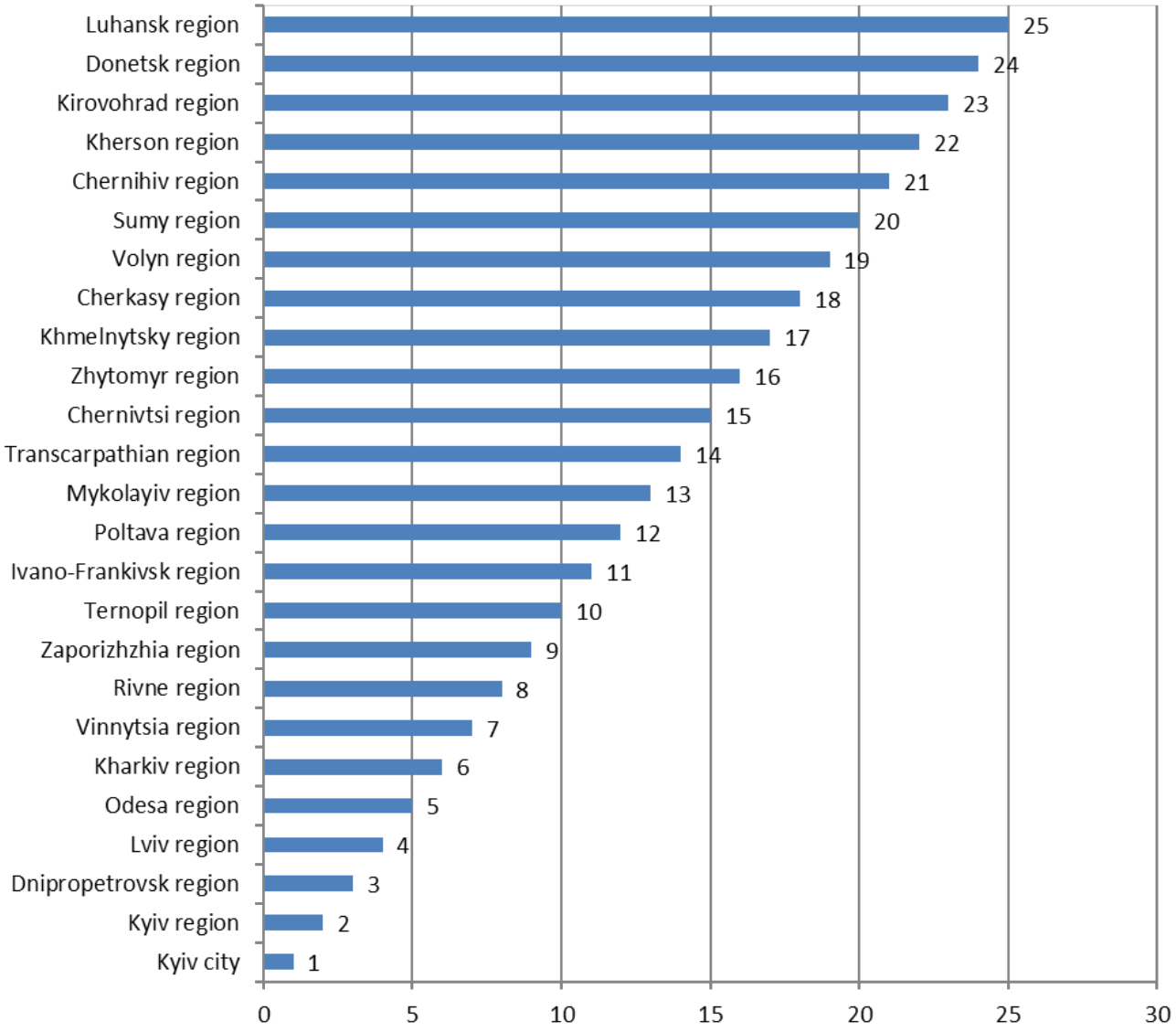

Figure 2. The overall place of the region in socio-economic development in 2021

Source: *Monitoring of socio-economic development of the regions of Ukraine* 2021.

Volyn has a clear European orientation. It participates in the Border Cooperation Program "Poland–Belarus–Ukraine 2007–2013", implemented as part of the EU under the European Neighborhood and Partnership Instrument. Currently, 32 regional cross-border direction projects with a total cost of €13 million are being implemented in Volyn. The most important projects in terms of socio-economic development of the region were:

1) the construction of a sewerage system in Shatsk, which will largely solve the problem of preserving the ecosystem of the Western Bug River valley in the border areas of Ukraine, Poland, Belarus, and Lake Svityaz (grant for the Ukrainian side: €2.0 million);

2) the construction of a hydrotherapy sanatorium in Gremyachensk village in the Kivertsy district and the purchase of equipment for it (grant for the Ukrainian side: €1.7 million);

3) the construction of 5.3 km of paved municipal roads in three settlements of Zabrodivka village in Ratniv district (grant for the Ukrainian side: €0.5 million);

4) the modernization of zoos in Lutsk and Zamość (grant for the Ukrainian side: €1.4 million);

5) construction of new buildings of the Lutsk City Hospital responsible for treating severe burns by purchasing equipment and medical equipment and through the exchange of knowledge and experience; conducting preventive and explanatory measures among the population (grant for the Ukrainian side: €0.25 million);

6) purchasing the necessary equipment for road maintenance in Shatsk and Wlodaw, preparing an interactive map and installing GPS systems on highways, conducting seminars for employees of organizations responsible for good condition of road infrastructure (grant for the Ukrainian side: €0.4 million);

7) implementing joint measures to increase the investment attractiveness of the cross-border area by establishing a cross-border agency to work with foreign investors (grant for the Ukrainian side: €0.2 million).

The Volyn region is also a participant in 4 infrastructure projects to modernize the state border, which is financed by the EU under the auspices of the Cross-Border Cooperation Program "Poland–Belarus–Ukraine 2007–2013":

1. The reconstruction of the "Ustyluh" international checkpoint for road connections;

2. Provision of new equipment and equipment to border service departments at the "Krakivets," "Shehyn," and "Yagodyn" checkpoints;

3. The development of IT infrastructure of the State Customs and Border Services of Ukraine on the Ukrainian-Polish border.

In total, Volyn received about €25 million from the EU to implement 32 regional and four national projects.

The implementation of the project "Restoration of the reclamation network to promote economic growth in rural areas of Volyn region" within the framework of the EU Program "Support to Regional Development of Ukraine" continues in the region. The EU has provided €1,171,859 in financial support for the implementation of the project.

The main activities of the project include restoring 240 km of reclamation network in 8 villages in the Kovel and Ratniv districts; purchasing equipment to analyze soil, water,

and agricultural products; conducting agrochemical surveys of soils; developing scientifically based recommendations on methods of agricultural management on drained lands; preparing measures to prevent soil degradation in reclaimed areas.

In particular, within the TACIS Program, large-scale projects were implemented, such as the construction of the "Yahodyn" International Road Checkpoint, which included constructing a second bridge over the Western Bug River, and the project "Reconstruction and Expansion of the International Road Checkpoint "Yahodyn" (first phase) on the Ukrainian-Polish border", thanks to which the infrastructure of the exit zone mentioned by international checkpoint was modernized. Between 2009 and 2011, the entrance zone to Ukraine at this border crossing was reconstructed.

Decentralization continues in Ukraine, and united territorial communities are being created. In particular, 39 United Territorial Communities have already been established in 45% of the Volyn region. Volyn is the leader in the number of communities that cover the maximum amount of territory.

In the Volyn region, four districts (rather than 16) were created, namely Volodymyr-Volynsky, Kovel, Kamin-Kashirsky, and Lutsk (Figure 3).

1. Lutsk – formed from the united Rozhysche, Kivertsy, Gorokhiv, and Lutsk districts. Includes 15 territorial communities (351 settlements). Population: 457,300; area: 5,248 square kilometers.
2. Volodymyr-Volynskyi – formed from the united Ivanychivskyi, Lokachynskyi and Volodymyr-Volynskyi districts. Includes 11 territorial communities (201 settlements). Population: 174,700; area: 2,558 square kilometers.
3. Kovel – the largest, formed from the united Turia, Shatsk, Starovyzhiv, Ratniv, Luboml and Kovel districts. It includes 23 territorial communities (380 settlements). Population: 271,000; area: 7,647 square kilometers.
4. Kamin-Kashirsky – formed from the united Manevychi, Lyubeshiv and Kamin-Kashirsky districts. Includes five territorial communities (155 settlements). Population: 132,400; area: 4,693 square kilometers.

Volyn region

Volodymyr-Volynskyi – 174,700 people, Kamin-Kashirsky – 132,400 people, Kovel – 271,000 people, Lutsk – 457,300 people

Figure 3. Areas of Volyn region in 2021

Source: *New rayons: maps and structure* 2020.

The stages of financing the City Comprehensive Program "Safe City of Lutsk" in 2019–2021 are in Figure 4.

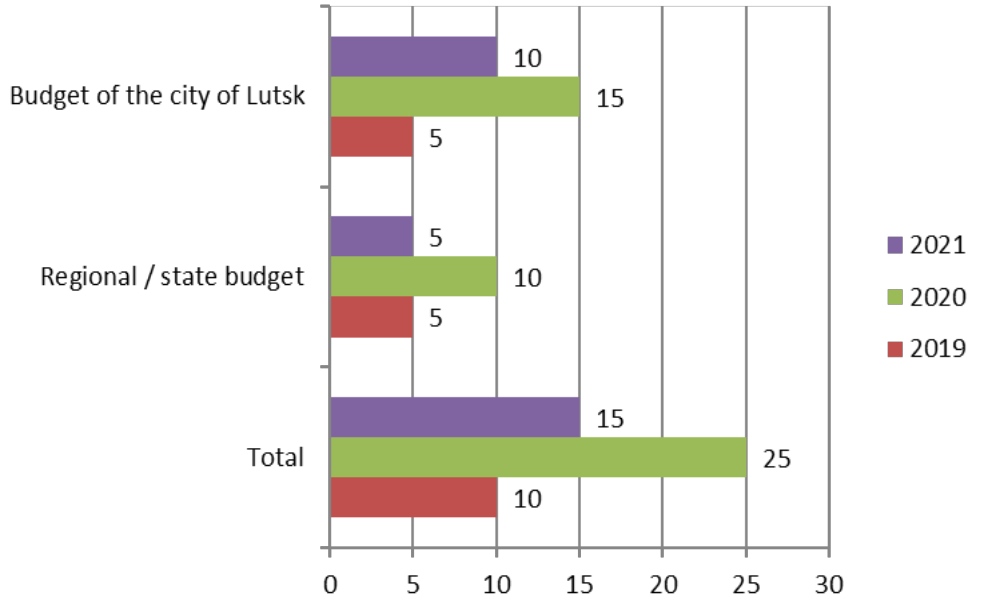

Figure 4. Stages of financing the City Comprehensive Program "Safe City of Lutsk" in 2019–2021, million UAH

Source: official site of Lutsk City Council 2019.

The project provides 50,000 UAH, of which 30,000 UAH is from the city budget and 20,000 UAH is from the state budget. The main technologies to increase security include video surveillance of strategic objects and public places, traffic control, and safety devices with high functional capabilities (alert sensors, police call buttons), technologies of a single fiber-optic network for law enforcement agencies to receive the information, a control center with software and equipment for control, analysis, and emergency prevention, and a system for alerting city residents about potential threats. The program's ultimate goal is to strengthen the security of the city's residents.

The amount of funding by source is given in Table 2.

Table 2. Financing of the City Comprehensive Program "Safe City of Lutsk" in 2019–2021 divided into areas, million hryvnias

Direction of spending within the program "Safe City of Lutsk"	City budget	State budget
Construction of fiber-optic communication lines with the installation of video surveillance cameras, 2019	2.4	4.1
Purchase and installation of software and hardware of intelligent video analytics system, 2019	2.6	0.9
Construction of video surveillance and notification systems in 55 microdistricts, Memorial, 900th Anniversary Park, schools, and educational institutions, 2020	9.0	6.3
Purchase and installation of video surveillance cameras and other elements of the Safe City system on newly built segments (air quality monitoring stations, police call buttons, SMART cameras for recognizing license plates of motor vehicles). Purchase and installation of software and hardware of intelligent video analytics system, 2020	6.0	3.7
Installation of additional SMART-stops in the city. Installation of "smart" boards, "Security Islands" and Alert System, 2021		2.0
Deployment of a video surveillance system in the city's public transport with a connection to the Situation Center		3.0
Construction of a new Crisis Management Center in Lutsk	10.0	
Together	30.0	20.0

Source: official site of Lutsk City Council 2019.

Lviv, Kyiv, and Odesa are also implementing "smart" technologies for remote automatic control of sensors, and data reading systems from metering devices to minimize costs, and with using a GSM communication channel. These technologies were integrated into Municipal Enterprise Lutskvodokanal's wells. It is planned to implement a "live" network management system at the Lutsksvitlo enterprise. This latest technology will be available for use in urban systems within the innovative smart city program.

In 2021, as part of the "Safe City" program, 670,000 UAH was spent installing 14 video surveillance cameras in Kovel at the entrance roads to Kovel, problematic crossroads, and in crowded places. At the Kovel station of the Lviv Railway regional branch, 100,000 UAH was spent installing 11 video cameras. The Safe City program in Kovel was presented in 2018.

In Volodymyr-Volynskyi, the Safe City program has been running since 2016 and includes 60 video surveillance cameras, which have proven their effectiveness.

In Kamen-Kashirskyi, within the Safe City program, it is planned to create a new video surveillance system with 14 cameras that can read vehicle license plates; 547,646 UAH was spent on this in 2022. The system will provide external video surveillance, real-time video streaming from video cameras, data collection and storage, information storage on hard drives, automatic synchronization of local video data with the archive of the centralized platform for collecting and accumulating information, detection of objects such as parked cars, dimensional objects, control and observation of crowds. Also, by the end of 2022, it was intended to renovate the street lighting network in Kamen-Kashyrskyi: installation of new reinforced concrete single-post supports and lighting fixtures, installation of a complete transformer substation, cable laying, and earthing installation; 1,466,975 UAH was to be allocated for these works.

Lublin case study

Lublin is the center of Lubelskie Province in Poland. The idea of a "Smart City" in Lublin and increasing the city's intelligence began with the adoption and implementation of the Lublin 2020 Strategy. It laid the foundations for the creation of the city's own smart development model. In the creation of a smart city 3.0, in which residents jointly create the city and have a real influence on decision-making, preference is given to social projects. This began in 2020, although the first attempts to implement a smart city were in 2016. The signs of the smart city of Lublin are the digitalization of economic, social, political, and administrative activities based on the principle of City as a Platform – CaaP (city geoportal, Lublin 3D, open data, participation portal, Mesh 3D model, point cloud, DMT and NMPT), overcoming transport and environmental problems (hybrid transport, Hajdów Photovoltaic Power Plant, remote reading of water meters, the management of water supply and sewage networks, programs to optimize heat networks, ekoAPP, a participation budget, a green participation budget, CityCard), Lublin virtual library, integrated IT systems for educational institutions, Let's Fix It Platform, free Wi-Fi, and smart city benches (Roman 2018, pp. 138–145).

The city of Lutsk and other cities of the Volyn region are characterized by Smart City 1.0, the signs of which are the development and increase in the number of technology firms and the lack of identified needs for new technological developments,

due to which cities use ready-made information solutions and products. It is important to create a strategy for the transition to Smart City 2.0, in which cities are interested in modern solutions; there are many individual projects on the market. For the countries of North-Eastern Europe, the transition to Smart City 4.0, which is complemented by spatial and technological intelligence with non-standard solutions, is important.

The main indicators of the development of Smart City 3.0 in North-Eastern Europe include more than 100 indicators that determine various aspects of the functioning of the city, grouped into 17 categories: economy, education, environment, finance, transport, energy, recreation, administration, security, waste, telecommunications and innovation, sewage, water and sanitation, health, spatial planning, shelter, and fire safety. Table 6 shows the main indicators of the development of Smart City 3.0 in Lublin.

Table 3. Separate indicators of the development of Smart City 3.0 in Lublin

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
1. Economy						
The level of unemployment, %	7.2	6.2	5.5	5.0	5.6	Employment rate (age 20–64)
Percentage of city residents living in poverty, %	2.88	2.46	2.07	1.69	1.67	
Percentage of people employed full time, %	36.52	36.92	37.4	37.38	37.04	
Unemployment rate among young people, %	8.4	7.6	8.1	8.0	9.0	Rate of youth non-participation in work (age 15–29) Rate of youth employment (age 15–29)
Number of firms per 100,000 population	13,062.68	13,354.72	13,350.13	13,590.99	14,200.82	
Number of new patents per 100,000 population per year	45.23	38.84	36.50	54.45	33.96	Patenting propensity

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
2. Education						
Percentage of girls attending school, %	99.7	99.86	99.83	N/A	N/A	Literacy skills of students Numeracy skills of students
Percentage of pupils who graduated from primary school: completion rate, %	99.9	N/A	N/A	N/A	99.75	
Percentage of pupils who graduated from high school: graduation rate, %	98.15	98.77	N/A	N/A	99.2	
Ratio of the number of school pupils to the number of primary school teachers	8.26	8.90	8.90	8.15	8.12	
Percentage of boys attending school, %	99.8	99.21	99.75	N/A	N/A	
...						
3. Energy						
Total electricity consumption by households per capita, kWh/year	99.98	99.98	99.98	99.948	99.999	Energy from renewable sources
Total energy consumption per capita, kWh/year	2.792	2.821	2.921	2.944	2.874	
...						
4. Environment						
Concentration of NO_2 (nitrogen dioxide).	21.7	21.7	21.6	19.0	17.2	Urban air quality – Nitrogen Dioxide
Concentration of SO_2 (sulfur dioxide)	3.8	5.2	4.8	4.8	4.4	Urban air quality – PM10
...						

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
5. Finances						
Debt service rate (debt service costs as a percentage of the commune's own income), %	2.84	2.89	2.77	2.78	2.16	Capital per capita Rate of bank loans non-performing entries to households (sic)
Capital costs as a percentage of total costs, %	11.76	16.32	20.16	13.81	11.81	
...						
6. Responding to emergency situations						
Number of freelance and volunteer firefighters per 100,000 residents	3.52	3.53	3.53	2.94	3.25	
Response time of the fire department from receiving the first call, min	7:06	7:00	7:00	7:23	7:29	
7. Administration						
Percentage of women employed in municipal administration, %	67.72	68.56	67.74	67.90	67.75	Female city managers
The number of registered voters as a percentage of the voting-age population, %	N/A	97.91	97.43	98.40	98.40	Voter turnout (European Elections) Voter turnout (Regional Elections)
...						
8. Health						
Average lifespan	78.5	78.34	78.1	78.15	77.00	Life expectancy at birth
Number of hospital beds per 100,000 population	1114.94	1130.79	1136.36	1018.29	1171.93	
Mortality under the age of 5 per 1,000 live births	3.5	4.75	6.08	4.15	5.02	Infant mortality
...						

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
9. Recreation						
The number of m^2 of closed public recreation places per resident	0.16	0.17	017	0.17	0.17	
The number of m^2 of outdoor public recreation area per resident	1.65	1.72	174	1.74	1.76	Diffusion of touristic farmhous-es Density of Historic Gardens
...						
10. Security						
The number of crimes against life per 100,000 residents	4.7	2.06	3.53	1.77	2.95	Other re-ported vio-lent crimes Reported widespread crimes
Crimes against prop-erty per 100,000 res-idents	1107.89	1240.55	906.85	892.92	912.03	Murders
...						
11. Shelter						
Percentage of urban residents living in slums, %	0.14	0.12	0.13	0.8	0.9	
The number of home-less people per 100,000 residents	91.93	81.55	N/A	81.52	116.66	
...						
12. Waste						
The total amount of solid household waste collected per capita, tons	0.34	0.35	0.36	0.4	0.4	Separate collection of municipal waste
Percentage of munici-pal solid waste that is recycled, %	9.63	9.28	16.95	17.04	16.52	
...						

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
13. Telecommunications and innovations						
The number of Internet connections per 100,000 residents	28,650	29,196	30,242	29,838	32,004	
...						
14. Transport						
Number of kilometers of high-capacity public transport system per 100,000 residents, km	9.02	12.06	11.31	13.59	13.64	Seats-km offered by local public transport
The number of kilometers of the public transport system per 100,000 residents, km	61.86	65.03	64.77	66,8	66.51	
...						
15. Spatial planning						
Green areas per 100,000 residents, ha	401.57	406.22	408.12	407.05	418.95	Urban green spaces
The annual number of trees planted per 100,000 residents	151.26	285.42	223.74	197.77	593.65	
...						
16. Sewage						
Percentage of city residents who have access to sewerage, %	96.63	96.1	95.95	95.82	95.11	
Percentage of municipal wastewater that has undergone primary treatment, %	100	100	100	100	100	
...						
17. Water and sanitation services						
Percentage of city residents who have access to drinking water, %	96.36	95.84	95.7	94.94	N/A	

Indicator	2016	2017	2018	2019	2020	Indicator BESdT
Total water consumption per person in the household, liters/day	95.62	93.97	94.54	93.15	92.88	
...						

N/A – no data available
Source: Smart City Lublin n.d.

Comparing Tables 1 and 2, it can be concluded that only some of the indicators from the proposed BESdT indicators used in Southern Europe (Italy) are calculated in Lublin. However, as evidenced by the data in Table 1, 48 of the proposed indicators can be calculated for cities in Eastern Europe.

BESdT assessment

BESdT indicators whose data are available for Ukraine are reported in Table 4.

Table 4. Adapted BESdT indicators for Ukraine in 2003–2021

Indicator (measurement unit)	2003	2008	2019	2020	2021
Class 1. Health, education and teaching					
Mortality of children under 1 year of age (per 1,000 live births)	9.6	10	7	6.7	N/A
Number of graduates from vocational education institutions (1,000 people)	275.6	269.6	124.0	114.1	112.4
Number of graduates from Higher Education Institutions (1,000 people)	579.4	623.3	383.8	386	262
Number of graduates from vocational education institutions and institutions of higher education (1,000 people)	855	892.9	507.8	500.1	374.4
Class 2. Balance between work and personal life					
Level of the employed population of working age as a % of the population of the corresponding age group	64.5	67.3	67.6	55.3	53.9
Class 3. Economic prosperity					
GDP per capita, at current prices (UAH million)	5.801		94.633		N/A
Class 4. Ecology and safety					
Waste disposal rate	2.06	2.50	4.09	4.60	N/A

Indicator (measurement unit)	2003	2008	2019	2020	2021
Class 5. Innovation and quality of services					
Part of the amount of implemented innovative products (goods, services) in the total amount of implemented products (goods, services) of industrial enterprises, (%)	5.8	4.8	1.3	1.9	N/A
Class 6. Politics and elections					
Level of turnout in local elections, (%)	69.3[a]	48.7[b]	46.6[c]	36.9[d]	N/A

[a] 31.03.2002; [b] 31.10.2010; [c] 25.10.2015; [d] 25.10.2020; N/A – no data available
Source: *Local elections in Ukraine…* 2020; Official data of the Main Department of Statistics in Volyn region n.d.; Official data of the State Statistics Service of Ukraine n.d.

Based on Table 3, it can be concluded that the number of graduates of higher education and vocational institutions has decreased rapidly. The working-age employed population also decreased, as did some implemented innovative products and the turnout in local elections. The following indicators achieved a positive trend: mortality of children under one year of age, waste disposal, and GDP per capita.

Table 5 shows the BESdT available indicators are assessed for the Volyn region.

Table 5. Adapted BESdT indicators for the Volyn region in 2003–2021

Indicator	2003	2008	2019	2020	2021
Class 1. Health, education, and teaching					
Mortality of children under 1 year of age (per 1,000 live births)	8.1	7.3	7.5	6.3	N/A
Number of graduates from vocational education institutions, 1,000 people	8	8.2	4.7	4.3	4.2
Number of graduates from Higher Education Institutions, 1,000 people	10.2	7	6.7	6.5	5.6
Number of graduates from vocational education institutions and institutions of higher education, 1,000 persons	18.2	15.2	11.4	10.8	9.8
Class 2. Balance between work and personal life					
The level of the employed population of working age as a % of the population of the corresponding age group	56.7	58.8	50.9	55.8	55.5
Class 3. Economic prosperity					
GDP per capita, at current prices, UAH million	3.339	12.34	73.192	75.193	N/A
Class 4. Ecology and safety					
Waste disposal rate	0.43	0.29	0.18	0.18	N/A

Indicator	2003	2008	2019	2020	2021
Class 5. Innovation and quality of services					
Part of the amount of implemented innovative products (goods, services) in the total amount of implemented products (goods, services) of industrial enterprises, %	N/A	24.7	0.7	1.4	N/A
Class 6. Politics and elections					
Level of turnout in local elections, %	N/A	N/A	55.29[a]	41.89[b]	N/A

[a] 25.10.2015; [b] 25.10.2020; N/A– no data available
Source: *Local elections in Ukraine...* 2020; Official data of the Main Department of Statistics in Volyn region n.d.; Official data of the State Statistics Service of Ukraine n.d.

From Table 4, it can be concluded that in the Volyn region, as in Ukraine as a whole, the number of graduates of higher education and vocational institutions has decreased rapidly, as did the mortality of children under one year. The working-age employed population decreased, as did some implemented innovative products and the level of turnout in local elections. The following indicators achieved a positive trend: waste disposal and GDP per capita. However, voter turnout is higher than the average data in Ukraine. In 2008, the implementation of some innovative products was the highest, and exceeded the Ukrainian average for 2008 five-fold. However, in 2019 almost all indicators fell below the national average.

We will compare Poland based on the individual BESdT indicators from 2003–2021 (Table 6).

Table 6. Selected indicators of BESdT for Poland in 2003–2021

Indicator	2003	2008	2019	2020	2021
Domain 1 – Health					
Life expectancy at birth, years	74.6	75.54	77.9	76.6	75.6
Infant mortality (per 1000 live births)	N/A	N/A	3.180	3.089	2.996
Domain 2 – Education and training					
Neet (young people who are not in education, employment or training), %	N/A	N/A	17.7	19.4	16.9 (women)
Literacy skills of students, %	N/A	N/A	99.8	99.8	99.8
Domain 3 – Work and work-life balance					
Rate of fatal accident and permanent disability, cases per 1,000 workers	N/A	N/A	N/A	4.62	5.1

Indicator	2003	2008	2019	2020	2021
Domain 4 – Economic prosperity					
Average income per head, PLN	N/A	1,046	1,819	1,919	2,062
Domain 6 – Politics and institutions					
Murders, number of cases	1,039	759	524	641	625
...					
Domain 9 – Environment					
Urban air quality – PM10	N/A	N/A	31.0	13.1	20.0
Domain 10 – Innovation, research and creativity					
Patent proposal, number of cases			3,946	4,058	3,430
Domain 11 – Quality of services					
Children who have benefited from municipal childcare services (up to 3 years), persons	N/A	N/A	143,574	142,355	163,416

N/A – no data available
Source: European Environment Agency n.d.; Global Data n.d.; GUS n.d.; Macrotrends n.d.; Nałęcz n.d.; Patent Office of the Republic of Poland n.d.; *Ilość zabójstw w Polsce...* 2020; GUS 2022; Rudke 2022; Eurostat 2023.

The table shows that in Poland and Ukraine, life expectancy in 2021 decreased to 75.6 years, the number of patents decreased to 3,430 units, and child mortality decreased. The development and implementation of Smart City strategies can be an impetus for development both in Poland and Ukraine.

Conclusions

The four generations of smart cities differ in density and use of digital technologies. Southern Europe has implemented Smart City 4.0. However, like some EU member states, Eastern Europe is developing and implementing strategies for third-generation smart cities. Meanwhile, other Eastern European cities still implement the Smart City 1.0 strategy. Such cities include the cities of Ukraine. The paper has established that about 48 BESdT indicators for assessing the well-being of smart cities can be used for the cities of Eastern Europe, using the example of Lublin. However, Lublin uses a different system to evaluate Smart City 3.0. In particular, it uses 110 indicators that are combined into 17 groups. Using the Italian methodology, it was established that out of the 48 indicators in Poland, 24 indicators were calculated. The other half can be calculated based on statistical data.

The differences in evaluation methods are primarily related to the difference in generations of smart cities. Since smart cities in Ukraine are of the first generation, it is

possible to calculate only 15 of the indicators proposed by the BESdT methodology. The smart city program in Lutsk, Volodymyr-Volynskyi, Kamin-Kashyrskyi, and Kovel provides the implementation of mobile projects that ensure the safety of citizens and make a convenient urban transport system. In Lutsk, "smart city" applies to economies and the introduction of "living" network management systems. However, they do not have projects that fully comply with the concept of a "smart place": 1) management – the introduction of technology in policy and strategy, e-office, and open self-government; 2) the economy (entrepreneurship and innovation) – finding solutions to stimulate entrepreneurship and innovation, and increase labor productivity and the communication of local and global markets; 3) the way of life of society – the interaction of people in society and the search for solutions in interaction; 4) human capital (creativity and innovation) – the formation of citizens' ingenuity and creativity; 5) education – investments in education and knowledge, including the education of the elderly and entrepreneurship education; 6) mobility – integrated transport system, ICT and support for environmentally friendly transport; 7) infrastructure – infrastructure solutions and technologies; 8) environment – sustainable development of the city through proper resource management, investment in green technologies, public and pedestrian transport.

The implementation of Smart City programs in Ukraine should occur by integrating technologies in energy, water supply, sewerage, transport, a city security system, medicine, and education. Smart technologies increase security by controlling and preventing possible risks in these areas. These processes are implemented together with the process of decentralization and the formation of a new structure of territorial communities.

To evaluate the smart city programs adopted by cities in the Volyn region based on well-being assessment, we used BESdT indicators (ISTAT 2019). However, considering the availability of data in the State Statistics Service of Ukraine, not all of them can be measured. Of the 55 proposed indicators, data can be obtained for only seven (infant mortality, the employment rate (ages 20–64), paid working days per year (employees), average income per capita, average annual income per employee, capital per capita, and the number of non-profit organizations). These indicators were used to assess smart city programs in developing territorial communities.

Analysis of BESdT indicators, which are adapted for Ukraine, showed the following trends:

1. A reduction in mortality rates among the population of Ukraine and Volyn region, improved health, and fewer graduates, but this is not related to the level of education and studying;
2. Imbalances in the relationship between work and personal life. Most Ukrainians of working age prefer to work abroad or rely on self-employment in subsidiary farms;

3. Increased economic prosperity, as indicated by the growth of GDP (GRP) per capita;
4. An improvement in the environmental component and security of society in the regional context;
5. Less innovation implementation in enterprises. The implementation of innovative products decreased in 2020 compared to 2018 by five times in the Volyn region;
6. A lower turnout in elections, which indicates a loss of confidence in the government. However, in the Volyn region, trust in the regional context is quite high;
7. Volyn region does not have a stable tradition of open political processes due to historical preconditions;
8. The positive changes in the Volyn region are not due to its internal self-development, but the actions of the central government, and centralism that applies to all spheres of activity;
9. Public organizations and business structures in the Volyn region are inefficient due to the lack of a single vector of development.

The vector of development and balancing the interests of public organizations, businesses and local authorities is the policy of reforming the territorial organization and creating four districts, the centers of which will become "smart" cities. Such an approach will accelerate the implementation of innovative products and revive the business reputation and welfare of local communities.

It is important to develop a unified methodology for assessing the well-being of smart cities of generations 1.0, 2.0, 3.0, and 4.0. The point of choosing indicators and conditions of their application is debatable. In further research, it would be worth paying attention to the BESdT indicators, which can be grouped into four blocks depending on the generation of Smart City.

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Inteligentne miasta dla zrównoważonego rozwoju społeczności lokalnych na przykładzie Wołynia i miasta Lublin

Koncepcja „inteligentnego miasta" jest aktywnie wdrażana przez kilka europejskich miast w celu poprawy jakości życia obywateli i zrównoważonego rozwoju na poziomie społeczności lokalnych. Celem artykułu jest ocena programów „smart city" przyjętych przez ukraińskie miasta na Wołyniu na podstawie oceny ich dobrostanu. W tym celu dokonano przeglądu literatury w celu zidentyfikowania wskaźników służących do oceny dobrostanu na poziomie lokalnym i przyjęto podejście *Benessere equo e sostenibile dei Territori* (BESdT, Sprawiedliwy i trwały dobrobyt obszarów). BESdT to instytucjonalne ramy pomiarowe opracowane przez Włoski Narodowy Instytut Statystyczny (ISTAT), mające na celu pomiar dobrostanu na poziomie lokalnym poprzez zbiór wskaźników obejmujących różne obszary dobrostanu. Wskaźniki BESdT dostępne dla Ukrainy i Polski zostały zebrane, a następnie zmierzone. Głównym celem badania jest wyjaśnienie możliwości wykorzystania wskaźników BESdT w ocenie inteligentnych miast w Europie Południowej dla krajów Europy Północno-Wschodniej na przykładzie Wołynia i miasta Lublin. W pracy przeanalizowano wskaźniki inteligentnych miast i przykłady ich rozbudowy w latach 2003–2021. Wyniki świadczą o tendencji wzrostowej w realizacji programów „inteligentnych miast" w kontekście regionalnym. Na Wołyniu priorytetowymi obszarami realizacji projektu są bezpieczeństwo, transport i energia elektryczna. W regionie tym można wyróżnić takie tendencje, jak zmniejszenie śmiertelności ludności, poprawa równowagi między pracą a życiem osobistym, wzrost dobrobytu gospodarczego

oraz poprawa komponentu środowiskowego i bezpieczeństwa społeczeństwa. Z drugiej strony zidentyfikowano również zmniejszenie wdrażania innowacji i utratę zaufania do władz. Z analizy wynika, że pozytywne zmiany, o których mowa powyżej, wydają się wynikać z działań władzy centralnej, a nie regionalnej. Na podstawie analizy ustalono, że kraje Europy Północno-Wschodniej wykazują poziom rozwoju inteligentnych miast Smart City 3.0, z wyjątkiem Ukrainy z poziomem rozwoju Smart City generacji 1.0 i Europy Południowej z poziomem rozwoju Smart City generacji 4.0.

Słowa kluczowe: inteligentne miasto, społeczność lokalna, zrównoważony rozwój, *Benessere equo e sostenibile dei Territori* (BESdT), budżet miasta