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MEASURING SUSTAINABLE SOCIAL INNOVATION AT MESO LEVEL. A HUNGARIAN CASE STUDY: THE CITIES OF BORSOD-ABAÚJ-ZEMPLÉN COUNTY

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Abstract

Rapidly changing economic conditions have brought new challenges for the cities of Borsod-Abaúj-Zemplén county in the Northern-Hungary region. The countys 28 towns are important spaces for residents, businesses and commerce, and are the fastest to bring new and innovative solutions to the county. The cities of Borsod-Abaúj-Zemplén county are examined in the framework of our study through the lens of sustainability and social innovation providing a meso-level analysis in the field of social innovation. Miskolc, a city with county rights, is excluded from the scope of the cities studied, as this would significantly distort the sample and the results of the methodology. For the sake of our analysis, we have highlighted and included 3 elements from the 17 UN Sustainable Development Goals (SDGs) adopted in 2018, which best reflect the concept of sustainable social innovation. As a result of our analysis, we have grouped the urban network of the county into 5 cluster groups. The aim of our analysis was to find out how the 28 cities of Borsod-Abaúj-Zemplén county perform along the 3 SDGs (Sustainable Development Goals) priority dimensions. To what extent do the development dynamics and liveability of cities differ? The methodology chosen for the analysis was clustering. The results obtained reflect the specifities of the county's urban network, the current economic situation of the region and the direction of its development. It can be concluded that, among the municipalities of the county, the dynamics and the liveability of most of the medium-sized and small cities, as well as of the settlements linked to the Miskolc agglomeration, are the most favourable in the region.

Keywords: sustainable social innovation, complex index, Hungarian cities, liveability, spatial inequalities, urban development

INTRODUCTION

Sustainable development – the responsible management of resources – has been a central issue in environmental and climate policy since 1987, following the preparation of the Brundtland Report.1 The document defines the concept of sustainable development as "development that meets the needs of the present generation without compromising the ability of future

[1] The document commonly known as the Brundtland Report: Our Common Future (1987): World Commission on Environment and Development. Oxford: Oxford University Press. 383 p. It outlined a form of economic growth that is robust, yet socially and environmentally sustainable (Li et al., 2024). This document was the first to define the concept of sustainable development, which had previously been mentioned by Meadows (1972) in his work "The Limits to Growth".

generations to meet their own needs” (Brundtland, 1987, p. 16). Nowadays, examining these issues is becoming increasingly essential for political decision-makers, as reflected in the United Nations’ 11th Sustainable Development Goal (SDG), which emphasizes making cities inclusive, safe, resilient, and sustainable (UN, 2018).

Three main pillars are commonly mentioned in relation to sustainability, all of which play a key role in urban development. These three pillars are the environmental, economic, and social dimensions of sustainability (Lehtonen, 2004; Sikos T. & Szendi, 2023; Kozma, 2024). The environmental pillar primarily encompasses environmental protection aspects (natural environment: biodiversity, resource and waste management). The social dimension represents equity, citizen well-being, and the fulfillment of basic human needs, while the economic dimension can refer to the economic competitiveness and diversity of urban areas (Toli & Murtagh, 2020).

This study examines 28 cities in Borsod-Abaúj-Zemplén County. Miskolc, as a city with county rights, was excluded from the analysis because its population size and economic potential would significantly distort the results of our chosen methodology. Borsod-Abaúj-Zemplén County is located in the north-eastern part of Hungary (the northernmost county in the country), one of the three counties of the NUTS2 region of Northern Hungary. Bordering Slovakia from the north, the county seat has historically significant connections with the city of Košice. The county’s topography is diverse, including the landscapes and mountainous areas of the Bükk National Park and elements of the Tokaj and Zemplén mountain ranges. Within the region, the distribution of settlements is uneven, with nearly 60% of the nearly 50 towns located in Borsod-Abaúj-Zemplén County. The average settlement size is significantly below the national average, as there are many areas with a small village structure in the county (more than 40% of settlements), which determine the county’s position in economic and demographic terms (HCSO data; Varga et al., 2021) and its peripheral position.

When selecting the study area, we also considered whether our model would function effectively in a region that is in a peripheral position based on socio-economic factors, we have thus verified the position of the county among the 19+1 counties of Hungary (the plus one is the capital city, Budapest[2]) (Tab. 1).

[2] The situation of Budapest and Pest County is unique in that it previously appeared together at the regional level as the Central Hungarian region, but since 2018 it has been listed separately, thus we treat the capital separately from the 19 counties.

Table 1 The Position of Borsod-Abaúj-Zemplén County Based on Selected Economic Indicators (2022)

	GDP per capita (thousand Ft)	Employment rate of the 15-64 age population (%)	Unemployment rate of the 15-64 age population (%)	Number of active enterprises per 1,000 inhabitants	Number of foreign enterprises per 1,000 inhabitants	Gross value added per capita (euro)	Share of the service sector in gross value added (%)
Position of Borsod-Abaúj-Zemplén County among the 19+1 counties of Hungary[3]	**15**	**17**	**18**	**20**	**16**	**15**	**17**

Source: Data from the Hungarian Central Statistical Office (HCSO) and Eurostat (2022).

Analysing the above data series, it is evident that Borsod-Abaúj-Zemplén County is one of the most disadvantaged regions based on almost all the economic indicators examined. With the exception of GDP per capita and added value, it ranks in one of the last five positions among the counties (its position in these two indicators is only one place higher).

A common characteristic of peripheral areas, as shown by the EU's Cohesion Reports, is that while they may improve their position in the long term, the distance from the centers remains significant, and they are unable to catch up with the EU average (European Commission, 2024). The reason for this is that these areas are predominantly rural, with low innovation and knowledge intensity, have generally low-income levels, are demographically disadvantaged, and have low technological innovation absorption capacity (Pike et al., 2006; Brucker & Finta, 2023). In these areas, due to the lack of traditional technological innovation, social innovation, which mainly builds on bottom-up initiatives, can be regarded as a breakthrough point that could contribute to the future development of the region. Innovation is an important indicator of the economic development and competitiveness of the counties. For example, improvements in innovation performance can enhance the competitiveness of countries (Ciocanel & Pavelescu, 2015; Cetin & Erkisi, 2023), which is why it is worthwhile to examine added value in relation to development and competitiveness. The literature is overwhelmingly focused on the examination of the innovation potential of regions, primarily due to its active contribution to economic growth and competitiveness (Szendi, 2018). However, when studying innovation, it is important to distinguish between technological and social innovation potential, as the absorption capacity of individual regions is not the same in these two cases. Regarding technological innovation potential, input-side factors generally include research and development expenditures and research institutions, while output-side

[3] Here, Budapest was included in the comparison, as by the ranking of counties it doesn't distort the results so much, as it is the first in almost all indicators, and the relative position of Borsod-Abaúj-Zemplén County is unchanged among the counties. So relative positions are not affected in the order-based comparison.

factors include patent activity, implemented developments, and publications. The definition of social innovation is more problematic, as there is still no universally accepted term for it. However, in most definitions, social innovation is interpreted by authors as the improvement of social/human well-being, the satisfaction of social needs, the bottom-up nature of innovation, or its novelty in addressing social needs that the market cannot meet. According to the OECD's valid definition, social innovation "seeks new responses to social and societal challenges and refers to new solutions aimed primarily at improving the quality of life of individuals and communities by increasing their well-being and social and economic inclusion" (OECD, 2024, p. 9). It is argued that in peripheral regions, due to the lack of traditional technological innovation, social innovation based mainly on bottom-up initiatives could provide the breakthrough point for future regional development (Murray, 2010; Kocziszky et al., 2015; Benedek et al., 2016; Mulgan, 2019; Torre, 2022).

Benedek and his co-authors (2020) examined the social innovation conditions of Hungarian settlements, and according to their findings, settlements most affected by complex problems were more frequently found in the border areas of the North Hungarian region, in the Central Tisza region, and the South Transdanubian region. This study primarily focused on the performance of non-profit organizations, unemployment patterns, and the proportion of social enterprises. The analysis concluded that high technological innovation potential and performance are not necessarily associated with high social innovation activity, which also suggests that even in peripheral areas where technological innovation is lacking, there is hope for high social innovation performance. However, random and occasional developments (social innovation activities) do not necessarily promote the catching up of the region; the nascent innovations should be sustainable in the long term, relying on the three pillars mentioned above (economy, society, environment). This issue could be resolved by calculating a complex social innovation index. For these reasons, we chose to analyze the 28 urban settlements in Borsod-Abaúj-Zemplén County. The basic data of the 28 cities, including Miskolc, are presented in Tab. 2.

Miskolc is the fourth most populous city in the country, and its favorable economic situation is attributed to the continuous growth of jobs. It is also the economic center of the Northern Hungarian region, and through the University of Miskolc, it plays a key role in the scientific, educational, and cultural life. Its regional role significantly impacts the development process of the area, as well as the living conditions of more than 200,000 people living in the Miskolc agglomeration zone (Miskolc and the surrounding settlements). This significant impact is the reason for its exclusion from the current study. In this study, we reviewed three of the

Sustainable Development Goals for the cities of the county based on 21 indicators. Based on the results, we classified the settlements into clusters and assumed that cities with similar characteristics and indicators could be grouped together.

Table 2 Key Data of the cities of Borsod-Abaúj-Zemplén County

Name of the city	Type of the city	Received city status	Population number		Domestic migration balance per 1,000 inhabitants, 2023
			1949	2023	
Miskolc	city with county rights	before 1885	109,841	148,906	-760
Kazincbarcika	Medium-sized city	1954	3,846	24,993	-207
Sátoraljaújhely		1899	17,116	13,876	-46
Ózd		1949	29,184	32,923	-102
Tiszaújváros	Small town	1966	1,349	14,669	-146
Mezőkövesd		1973	18,228	16,095	43
Szerencs		1984	7,813	8,757	77
Encs		1984	2,999	6,324	24
Sárospatak		1968	13,644	11,357	-66
Edelény		1986	4,908	9,671	20
Tokaj		1986	5,074	3,617	-3
Szikszó	Village-cities that also include urban functions	1989	5,589	5,496	-29
Sajószentpéter		1989	7,455	11,817	28
Mezőcsát		1991	6,335	5,867	-24
Putnok	Urban sprouts	1989	5,175	6,730	-40
Gönc		2001	3,252	1,966	-12
Felsőzsolca	Cities without a significant urban role	1997	2,932	6,804	-24
Cigánd		2004	5,203	3,109	-102
Emőd		2001	4,343	5,028	-17
Abaújszántó		2004	4,567	2,827	-18
Alsózsolca		2007	3,093	5,678	-87
Szendrő		1996	3,312	4,090	-65
Nyékládháza		2003	2,369	5,168	10
Onga		2013	2,515	4,951	-7
Mezőkeresztes		2009	5,391	3,694	2
Borsodnádasd		2001	3,511	2,979	-41
Sajóbábony		2009	867	2,647	-5
Rudabánya		2008	2,677	2,478	16
Pálháza		2005	735	1,059	-3

Source: Beluszky, P. & Sikos T., T. (2020): Városi szerepkör, városi rang [City role, city rank] and HCSO data, compiled by the author.

In their 2020 work on the Hungarian settlement network, Beluszky, P. and Sikos T., T. distinguished seven hierarchical levels, and we applied this classification to the cities of Borsod-Abaúj-Zemplén County as a starting point for the research. In this study, our goal was to determine to what extent the classification would align with the established cluster groups (see later).

These are as follows:

- Capital City
- Regional centers (with effect and catchment areas extending across multiple counties)
- County centers (not necessarily the same as county seats)
- Medium-sized cities
- Small towns (mostly corresponding to district seats in the administrative hierarchy)
- “Village-cities”, these towns only have urban functions in their early stages of development
- “Ceremonial towns” (from a settlement science perspective, they are not part of the city stock; thus, the urban hierarchy is effectively six-tiered).

Among the cities of Borsod-Abaúj-Zemplén County, only 10 cities have a real urban role, and these include medium-sized and small towns. These towns are mostly located in the narrower or broadly interpreted catchment area of Miskolc. A significant number of towns with locally employed industrial workers are also found along the Borsod industrial axis, in the strongholds of the chemical industry (Kazincbarcika 48.1%, Sajóbábony 66.9%, Tiszaújváros 69.8%). These were the flagship towns of socialist heavy industry and its beneficiaries. However, in case industrial development did not coincide with urbanization or other elements of functional growth, these towns were left behind and ended up in the last positions in the towns’ dynamic order, e.g., Rudabánya, Borsodnádasd, Sajóbábony, Sajószentpéter, or Ózd. Several “flagship” cities from the socialist era in Borsod-Abaúj-Zemplén County have entered a phase of decline; 11 of the country’s 31 most disadvantaged cities are located there.

In our study, we seek to analyze the performance of the 28 cities of the county along the three key dimensions of Sustainable Development Goals, which simultaneously reflect the cities’ readiness for social innovation and their sustainability dimensions. This enables us to find out whether it is the performance in sustainability goals or the position in the urban hierarchy that defines the position of each city. During the analysis, we attempted to create a complex index and identified homogeneous city groups by forming clusters.

SUSTAINABLE SOCIAL INNOVATION

Social innovation, according to its most commonly used definitions, aims to address social needs that the market cannot satisfy. This new form of innovation can promote the convergence process of peripheral areas by creating new ideas and initiatives (Kocziszky et al., 2015; Benedek et al., 2016; Micelli et al., 2023; Starti et al., 2023). Due to the lack of traditional technological innovation, social innovation, which is primarily based on bottom-up initiatives, can be seen as a breakout point for future regional development (Le Ber & Branzei, 2010; Lin & Chen, 2016). Common points of these definitions include improving societal well-being, addressing social needs, bottom-up initiatives, or the innovative nature of addressing social needs that the market cannot meet. Other studies highlight the significant role of the promotion of social empowerment (Tóth & Varga, 2024). According to the European Commission, "Social innovation can be defined as the development and implementation of new ideas (products, services, and models) aimed at fulfilling social needs and creating new social relationships or collaborations." (European Commission, 2013, p. 6).

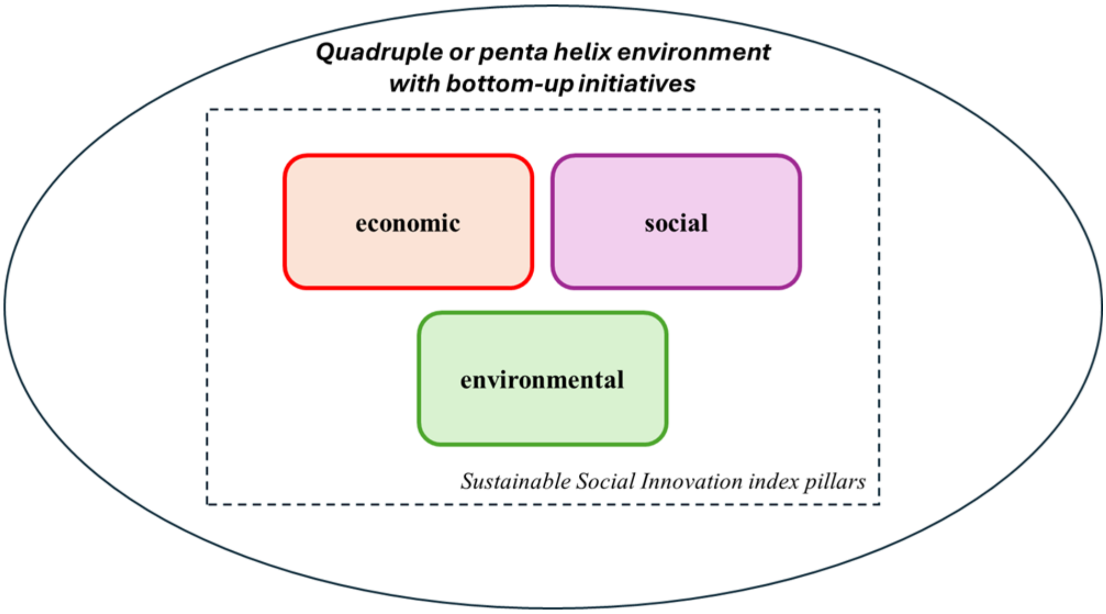
Sustainable social innovations are novel solutions that help address social problems and, in the long term, serve sustainability (Tinlab, 2021). These goals integrate the classic three pillars of sustainability: environmental, economic, and social aspects.

Sustainable social innovation is built on the following elements:

- Social impact: It primarily focuses on solving social problems, such as poverty, inequality, education, healthcare, and environmental sustainability.
- Sustainability: In addressing social problems, the environmental sustainability aspect is crucial, alongside economic and social considerations. This ensures that innovation targets not only short-term issues and does not endanger the ability of future generations to meet their needs.
- Collaboration: It involves the cooperation of various stakeholders, including governments, nonprofit organizations, businesses, and communities, in a triple (Leydesdorff, 2000) or quadruple helix (Alfonso et al., 2012) approach.
- Scalability and repeatability: Successful innovations are characterized by scalability and repeatability.

However, the conditions for social innovation (social embeddedness, acceptance, presence of bottom-up initiatives) can vary by region. This can significantly influence the success of individual innovations in the long term. To ensure the sustainability of social innovations, it is advisable to measure the performance of different regions according to the three pillars of sustainability and to determine the long-term sustainability of activities within a complex index framework. The model below integrates both the conditions for social innovation and the dimensions of sustainable innovations together with the best working helix condition for implementing innovations (Fig. 1).

Figure 1 Framework model of Sustainable Social Innovation



Source: Compiled by the authors.

In order to achieve long-term sustainable innovations, in addition to the above, it may be necessary to organize already developed or planned social innovations into a network, as international literature also suggests (e.g., Merlin-Brogniart, 2019; Desmarchelier et al., 2020), which can lead to spillover effects, thereby enhancing the effectiveness of the innovations and developments implemented, and further improving overall social well-being.

However, the success of applying the framework model can be significantly influenced by factors such as the involvement and influence of civil society (as also argued by Bródy, 2022). There are three relevant approaches in the practice of involvement, with the oldest one being the so-called triple-helix model, which builds on the cooperation of the public, private and academic fields in a fundamentally top-down manner. Hence, civic engagement is quite weak (Calzada & Cowie, 2017). Conversely, the quadruple-helix also integrates civic society and does so in an institutionalised bottom-up framework (Szendi, 2021). And lastly, the penta-helix model integrates the participation of the social entrepreneurs and activists in a proactive model (Calzada, 2020). The above model takes a quadruple helix approach, which not only considers the cooperation between the government, private sector, and academia, but also integrates civil society. This enables a more flexible response to social problems and creates an institutionalized, bottom-up framework for problem solving (Calzada, 2020).

METHODOLOGY

Similarly to social innovation, sustainable social innovation has no unified definition or calculation method so far. Therefore, to explore the database for sustainable social innovations (applicable indicators), we also utilized the opportunities offered by artificial intelligence (AI). This proved useful as no specific database is available to describe the examined issues, which allowed for a broad search and setting the framework for data mining expansion. Below, we provide the names and access points of the database collected by ChatGPT Plus:

1. **Sustainable Development Goals (SDG) Indicators Database**
   - **Description**: This database is used to track the implementation of the UN Sustainable Development Goals (SDGs) and contains data on indicators related to various goals. It provides data in areas such as poverty reduction, healthcare, education, gender equality, clean water, and climate protection.
   - **Access**: SDG Indicators Global Database
2. **Human Development Reports (HDR)**
   - **Description**: Reports published by the UN Development Programme (UNDP) provide data on various human resource development indicators, including education, income, health, gender inequality, and other socio-economic factors.
   - **Access**: Human Development Reports
3. **World Bank World Development Indicators (WDI)**
   - **Description**: The World Bank's WDI database contains a broad range of economic, social, and environmental data, often featured in UN reports and analyses.
   - **Access**: World Development Indicators
4. **UNESCO Institute for Statistics (UIS)**
   - **Description**: Provides data related to education, science, culture, and communication, including areas of educational access, quality, and innovation.
   - **Access**: UNESCO Institute for Statistics
5. **Global Innovation Index (GII)**
   - **Description**: While the GII is a joint initiative of Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), it is also frequently

featured in UN analyses. The index measures the innovation performance of countries, which can reflect various aspects of social innovation.

   - **Access**: Global Innovation Index

6. **UN Environment Programme (UNEP) Data**
   - **Description**: Provides data and reports related to environmental indicators, including climate change, biodiversity, and pollution, which are relevant to the environmental aspects of social innovation.
   - **Access**: UNEP Data
7. **UN Data**
   - **Description**: A comprehensive data portal that gathers statistics from various UN organizations on topics such as population, health, agriculture, education, and environmental protection.
   - **Access**: UN Data
8. **UN Global Compact Reports**
   - **Description**: Contains data and case studies on corporate sustainability initiatives, highlighting the private sector's role in social innovation in line with UN principles.
   - **Access**: UN Global Compact

The above databases help assess the impact and progress of sustainable social innovations and provide a foundation for planning, implementing, and developing innovation initiatives. These types of databases and reports allow policymakers, researchers, and developers to identify gaps, uncover opportunities, and establish the long-term sustainability and social usefulness of innovations. For the purpose of this study, we selected the "Sustainable Development Goals Indicators" database from the above-mentioned sources. The choice is explained by the reasons outlined above, but the list also offers paths for analysis along different routes. In other words, for measuring sustainable social innovation at the county level, it is possible to apply various databases, which can assist in the analysis, interpretation, and control of the results. At the turn of the millennium, the focus of the UN's Millennium Development Goals was on the issues of developing countries. Fifteen years later, a sustainable development program was created that, in addition to the previous focus, also considered the perspectives of developed countries. This program ("Transforming our World: The 2030 Agenda for Sustainable Development") included 17 global sustainable development goal programs and 169 targets (European Environment Agency, 2020), with a particular emphasis on the environmental dimension (HCSO, 2022; UN, 2015). By 2020, the UN had developed methodologies for all indicators (HCSO, 2022). In our study, we selected three sustainability goal programs from the 17 targets (targets 8, 9, and 11).

For the purpose of our study, sustainability and smart economy (innovation capacity) were the main focus. Among the Sustainable Development Goals, there are several that focus not only on environmental sustainability but also on economic sustainability. When selecting the 8th, 9th, and 11th components, our main aim was to examine the environmental and economic sustainability dimensions, in order to find out whether economically more developed cities can be sustainable in terms of environmental, economic, and social aspects.

When selecting the target indicators, we also aimed to include indicators of social innovation as well as the dimensions of sustainability among the selected dimensions. Several previous analyses can provide a basis for this, which associate each SDG with the pillars of sustainable development (e.g., Kostoska & Kocarev, 2019; Paoli & Addeo, 2019; or Mangukiya & Sklarew, 2023). The 8th and 9th goals were incorporated among the economic dimensions as they represent the characteristics of the region most accurately (strong industrial history, jobs, and economic growth). Inequalities between the cities of the county were integrated into income data. Among the social goals, we focused on sustainable cities and communities which most closely embody the concept of sustainable, innovative cities. We also included climate goals and cleaner energy use in this indicator group. There are several goals that are less relevant in the context of this meso-level analysis.

We also integrated indicators measuring pure social innovation potential into most of the goals, thus ensuring their measurability in the complex index (8. number of individual entrepreneurs and civil organizations; 11. recipients of municipal support, number of cultural institutions, educational institutions).

Thus, in total, we examined two economic goals: 8. decent work and economic growth; 9. industry, innovation, and infrastructure; and one social goal: 11. sustainable cities and communities (Tab. 3).

In our analysis, we examined how the 21 target indicators (Tab. 3) interact with each other. In this study, we conducted an analysis of the 28 cities of Borsod-Abaúj-Zemplén county based on three SDG index values (8th, 9th, and 11th target indicators). The novelty of the city-level analysis lies in the fact that, to date, no similar methodology has been used for meso-level analysis. It is important to note that at the meso level, indicator selection is significantly more challenging due to the limited availability of reliable variables. Many indicators must be excluded from municipal-level analyses because they are only available at the county level in the databases. Examples of such indicators include research and development activities (both input and output sides, such as expenditures and patents), various satisfaction-related data, or even some infrastructure indicators.

Table 3 List of Indicators Used in Each Dimension

SDG Dimension	Indicator	Literature source	Data source/ data base
8. Decent work and economic growth	Net income per capita (the amount of net income, which forms the basis for personal income tax, per permanent resident)	Lafortune et al. (2019): The 2019 SDG Index and Dashboards Report for European Cities – **hereinafter referred to as Lafortune et al. (2019).**	HCSO – Dissemination database
	Number of unemployed persons registered for more than 180 days per 1,000 inhabitants	Lafortune et al. (2019)	HCSO – Dissemination database
	Old-age dependency ratio (65+ / 15-64 years)	HCSO (2022): Sustainable Development Goals – **hereinafter: HCSO (2022)**	HCSO – Dissemination database
	The proportion of active individual entrepreneurs (%)	HCSO (2022)	HCSO – Dissemination database
	The proportion of secondary school graduates (%)	HCSO (2022)	HCSO – Dissemination database
	The number of civil organizations per 1,000 inhabitants	HCSO (2022)	HCSO – Dissemination database
	The percentage of employed individuals in the resident population	HCSO (2022)	HCSO – Dissemination database
9. Industry, innovation, and infrastructure	The number of internet subscriptions per 1,000 residents	Lafortune et al. (2019)	HCSO – Dissemination database
	CO_2 emissions per capita (tons)	HCSO (2022)	OKIR – LAIR
	Domestic migration balance (permanent and temporary) per 1,000 inhabitants, 2020	Lafortune et al. (2019)	HCSO – Dissemination database
	Travel time to the county seat by road (fastest, in minutes)	Lafortune et al. (2019)	Google Maps route planner
11. Sustainable cities and communities	Per capita NO_2 emissions (kg/year)	Lafortune et al. (2019)	OKIR – LAIR
	Average property price per square meter	Lafortune et al. (2019)	ingatlannet.hu

Table 3 (continued)

SDG Dimension	Indicator	Literature source	Data source/ data base
	Financial aid (Number of people receiving municipal support as a percentage of the population)	Lafortune et al. (2019)	HCSO – Dissemination database
	Number of cultural institutions per 100,000 inhabitants	Lafortune et al. (2019)	Hungary's attraction map; Google Maps
	Number of attractions per 100,000 inhabitants	Lafortune et al. (2019)	Hungary's attraction map; Google Maps
	Number of museums per 100,000 inhabitants	Lafortune et al. (2019)	Hungary's attraction map; Google Maps
	Number of educational institutions per 10,000 inhabitants	HCSO (2022)	HCSO – Dissemination database
	Secondary utility gap (discrepancy in the proportion of households connected to water and sewage networks)	HCSO (2022)	HCSO – Dissemination database
	The proportion of selectively collected waste in total waste collection (%)	Lafortune et al. (2019)	HCSO – Dissemination database
	The amount of support received per capita for the development of renewable energy sources through GINOP grants (HUF)	HCSO (2022)	palyazat.gov.hu

Source: compiled by the authors.

When selecting indicators, we aimed to choose data sets that are accessible both for international and domestic cities, and that could allow our study to be reproduced in other timeframes and regions as well. The primary data sources were TEIR[4] and the HCSO Dissemination Database. Two main sources of literature provided the foundation for the analysis, both in terms of methodology and the selected indicators. During the creation of the database, we relied on 2020-2021 data, as these were the most recent and thus most suitable for the analysis of cities in Borsod-Abaúj-Zemplén county.

A key aspect during the creation of the database was the comparability of the data series and their potential to be aggregated to create a composite index. Accordingly, as an initial step, we calculated specific data, mostly based on values per 1,000 or 10,000 inhabitants, or applied

[4] TEIR: National Regional Development and Spatial Planning Information System makes statistical data of different data owners available in one system, supporting planning and evaluation activities from the national to the local level.

percentage distribution. Since the data did not contain uniform units even after calculating specific values, it was necessary to apply standardization for calculating the components. By transforming/scaling the data, we made the indicators comparable. We performed the standardization according to the following formula (1).

$$x = \frac{x_i - x_{min}}{x_{max} - x_{min}} * 100 \quad (1)$$

For the indicators where a higher value had a more unfavorable meaning (e.g., the number of unemployed people or various air pollution measurements), we continued the calculation with the reciprocal of the values (2).

$$x_{corr} = \frac{x_i - x_{max}}{x_{min} - x_{max}} * 100 \quad (2)$$

The main advantages of the method are:

- It allows the aggregation of datasets with different units of measurement (e.g., kg, %, m^2…) while preserving the original relationships.
- It does not cause data loss or distortion (Giffinger et al., 2007; Cohen, 2014).

Subsequently, we formed complex components from the indicators by applying a simple arithmetic average[5], thus generating the values for the SDG8, SDG9, and SDG11 indices, as well as the complex sustainability index based on these, which can measure sustainable social innovation according to its individual pillars. This way, the index can also provide insights into the long-term development prospects of the settlements along each dimension.

An interesting question during the compilation of the datasets is which indicator's removal from the analysis impacts the distribution of results most significantly (sensitivity analysis). To this end, we reviewed the dispersion of standardized values, which indicated that less influential indicators include air pollution data (carbon dioxide and nitrogen oxides), as well as the number of people receiving municipal aid. In contrast, there is greater dispersion in the income data, the dependency ratio of the elderly, migration data, and the utility gap. A more significant outlier value can be observed in the distribution of individual entrepreneurs, specifically in the town of Nyékládháza, which could slightly distort the results.

[5] Since the values of the indicators were standardized when calculating the components, no outlier values remained in the database, which justified the application of the arithmetic mean (Semanjski, 2023).

RESULTS

The grouping of cities was carried out through cluster analysis. The selected method is suitable for exploring the relationships between the indicators of heterogeneous objects and for forming homogeneous groups (Anderberg, 1973). After several iterations with the indicators, we finally accepted a five-cluster solution (Tab. 4). The complex index values calculated for each city based on the indicators of SDG8, SDG9, and SDG11 are presented in Tab. 4. The achievement status of the targets is indicated for the component values. In the studies of Lafortune et al. (2019), performance thresholds of 20% were defined for the performance of cities, where capitals with performance above 80% received the highest ratings. Regarding the settlements in the county, after reviewing the interpretation range of each dimension and the complex index, the clusters were classified as follows:

- Above 60% – Small towns with liveable[6] conditions;
- 50-60% – Cities with cyclical development but liveable conditions;
- 40-50% – Cities with below-average living conditions searching for their place;
- 30-40% – Cities without a real urban role, difficult to live in;
- Below 30% – Lagging cities with unfavourable conditions.

Cluster A: Small towns with liveable conditions

The first cluster includes only two towns: Tokaj (with a permanent population of 3,371) and Nyékládháza (with a permanent population of 5,180). The development of the Tokaj region is rooted in its history, as it served as an important crossing point at the confluence of the Tisza and Bodrog rivers and established connections between the Tokaj Hills and the Great Hungarian Plain. Tokaj has long been significant for its wine trade, as it was part of the so-called "market town agglomeration" (Beluszky & Sikos T., 2020), and it continues to play a key role in shaping the wine trade in the Tokaj region, its wine tourism, and in creating tourism destinations based on this image. Currently, there are 35 major wineries in and around Tokaj. The town has around 18 accommodation facilities, including a 4-star hotel. The town's historical diversity is reflected in its religious variety (6 different churches), cultural wealth (art and writing camps, 6 museums, 47 sights), which has significantly contributed to the town's development. These opportunities open the way for further development, strengthening its economic, tourism, and cultural roles, thereby enhancing the local social innovation capacity.

[6] By livability, we mean factors such as the quality and availability of public services, housing and sustainability, which provide adequate conditions for residents from an economic, social and environmental perspective.

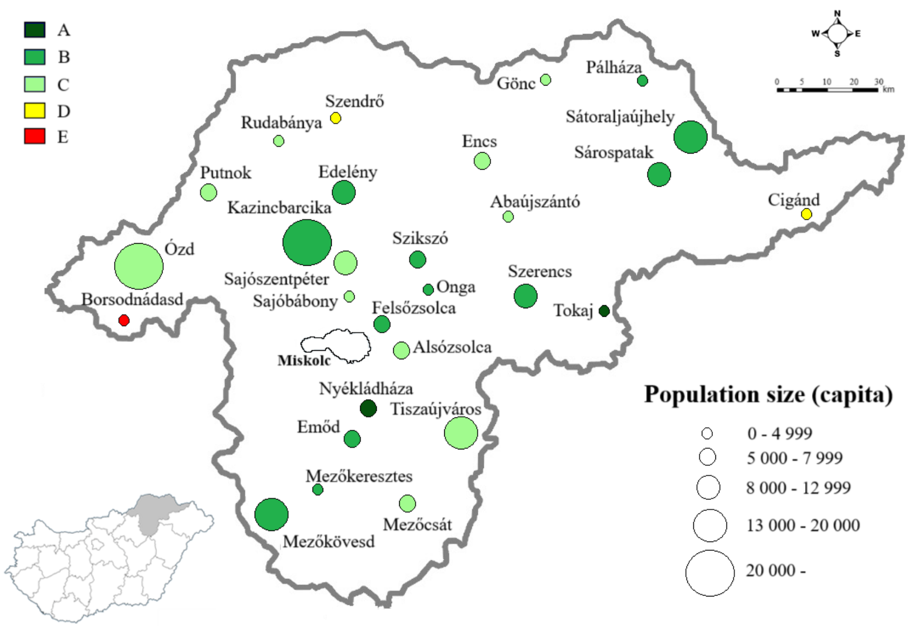
Table 4 Clusters of the Complex Sustainable Social Innovation Index

cluster	city	8	9	11	complex
A – Small towns with liveable conditions	Tokaj	52.1	73.0	68.8	64.6
	Nyékládháza	56.0	84.9	41.7	60.9
B – Cities with cyclical development, but liveable conditions	Felsőzsolca	49.4	76.1	46.8	57.4
	Pálháza	66.4	51.6	53.4	57.1
	Mezőkövesd	48.9	65.4	50.8	55.0
	Szikszó	50.1	69.0	45.7	54.9
	Sátoraljaújhely	50.4	48.5	62.1	53.7
	Emőd	50.9	70.8	39.1	53.6
	Onga	52.3	67.1	39.8	53.1
	Szerencs	50.8	71.8	31.4	51.3
	Mezőkeresztes	45.7	68.6	39.6	51.3
	Kazincbarcika	56.3	57.4	39.2	51.0
	Sárospatak	53.6	43.4	55.4	50.8
	Edelény	44.3	69.9	36.8	50.3
C – Cities with below-average living conditions, searching for their place	Mezőcsát	41.9	59.8	46.8	49.5
	Sajószentpéter	44.5	67.4	33.9	48.6
	Alsózsolca	44.0	61.0	40.3	48.4
	Encs	37.0	66.9	36.6	46.9
	Abaújszántó	44.3	51.7	43.5	46.5
	Sajóbábony	37.3	59.9	41.4	46.2
	Rudabánya	38.0	54.1	43.9	45.3
	Ózd	32.5	67.1	33.6	44.4
	Putnok	36.5	56.2	39.4	44.0
	Gönc	33.3	44.2	53.5	43.7
	Tiszaújváros	64.4	33.5	29.9	42.6
D – Cities without a real urban role, difficult to live in	Szendrő	24.7	43.9	45.1	37.9
	Cigánd	23.9	39.4	40.4	34.6
E – Lagging cities with unfavourable conditions	Borsodnádasd	20.3	36.6	29.2	28.7

Source: compiled on the basis of the authors' calculation.

Nyékládháza's prominent position is due to its role as a dormitory town and its close connection to the Miskolc agglomeration (Miskolc is 24 minutes away). Both small towns perform well in the 9th "Industry, Innovation and Infrastructure" and 11th "Sustainable Cities and Communities" SDG targets, with the highest calculated complex index values for Tokaj (64.6) and Nyékládháza (60.9). These values are attributed to the favourable environmental parameters and the lack of heavy industry in both towns. The two towns also perform well in the aforementioned social innovation data sets. Tokaj has the highest proportion of civil organizations, municipal support, and educational institutions. Nyékládháza is outstanding only in terms of the proportion of people receiving municipal support, which is over 90%. In terms of CO_2 emissions, both Tokaj and Nyékládháza report 0 tons, and they show similar values for NO_2 emissions (kg/year). The number of jobseekers registered for more than 180 days is more favourable in Nyékládháza (66 people), thanks to its proximity to Miskolc, while in Tokaj, the number is 131, which is still well below the average of the 28 cities. The per capita net income forming the basis of personal income tax in 2022 was 4,485 € for Tokaj, slightly above the average of the 28 cities (4,465 €), while Nyékládháza had the highest value of the cities under study at 5,859 €. This value was influenced by Miskolc's proximity and better-paying job opportunities. Tokaj and Nyékládháza are among the cities that balance the fulfilment of the 8th, 9th, and 11th SDGs, which also contributes to their liveability (Fig. 2).

Figure 2 Clusters and distribution of the Complex Sustainability Index



Note: A – Small towns with liveable conditions; B – Cities with cyclical development, but liveable conditions; C – Cities with below-average living conditions, searching for their place; D – Cities without a real urban role, difficult to live in; E – Lagging cities with unfavourable conditions.
Source: Own creation.

Cluster B: Cities with Cyclical Development but Liveable Conditions

The 12-element cluster includes both long-established cities and former "socialist" cities, such as Kazincbarcika, as well as the suburban towns of the Miskolc agglomeration. There is also an "outlier" in the cluster, Pálháza, which was included due to its favourable environmental and labour market data (only 18 registered jobseekers for over 180 days). The cluster also includes Sárospatak and Sátoraljaújhely, which were once the market centers of the Bodrogköz region and are still significant towns in the area today. Sárospatak's status is further strengthened by being a famous university town and since 2021, it has hosted a branch of the Tokaj-Hegyalja University. In both towns, the per capita domestic income forming the tax base exceeds the average of the 28 cities (Sárospatak 5,144 €, Sátoraljaújhely 4,750 €). Szikszó became the "county seat" of Abaúj-Torna County due to the Trianon border changes. This role was lost in 1950 with the county's unification, and henceforth, it has had a modest market role as a district seat. The most significant change in the life of the town in recent years is the arrival of HELL energy drink factory, which is a major employer, however, despite its presence, the per capita domestic income is only slightly above the average of the 28 cities (4,853 €). Larger cities, such as Miskolc, attract numerous agglomerated towns from their surroundings. This is reflected in the complex sustainability index values of towns such as Alsózsolca, Felsőzsolca, Nyékládháza, Emőd, and Onga. This group also includes Kazincbarcika, a former "socialist" city that was established in 1954. Its development is largely reliant on the chemical industry, particularly the Borsod Chemical Plant, later known as BorsodChem. In 1992, the chemical plant employed 4,527 people. Over time, the factory has undergone significant transformation, and by 2023, the number of employees had decreased to 3,728. Naturally, the factory has undergone significant modernization over the years, along with profile refinement. However, the environmental impact of the chemical plant is still not satisfactory. Air pollution is high (CO_2 emissions of 342,978,902 tons, NO_2 emissions of 415,563 kg/year), with only Tiszaújváros having worse values among the cities under review. However, the per capita domestic income forming the tax base is favourable (5,670 €), ranking third among the cities. Some towns show an outstanding performance in terms of social innovation data, providing potential points of breakthrough in their development. For example, Onga has the highest rate of individual businesses, Pálháza stands out in the number of civil organizations (second-highest rate), and Mezőkövesd has the highest proportion of people receiving municipal support.

Cluster C: Cities with Below-Average Living Conditions, Searching for Their Place

The 11-element cluster can be divided into three subgroups:

1. Medium-sized and small towns (Ózd, Encs, Tiszaújváros),
2. Towns closely linked to the Miskolc agglomeration without a significant urban role (Alsózsolca, Sajószentpéter, Sajóbábony),
3. Towns with emerging urban characteristics (Mezőcsát, Putnok, Gönc).

The fate of mining towns has essentially been sealed by post-regime change industrial policies (Putnok, Rudabánya). In the Putnok Black Valley mine, several tens of millions of tons of expensive-to-extract brown coal remained unextracted, and this partly applies to the mines around Ózd as well. Ózd was further burdened by the closure of its steelworks, contributing to the stagnation of the town's development and the onset of its "agonizing" process. Among the

28 cities in the county, evidently, Ózd has the highest number of unemployed, with 1,442 people, and its per capita domestic income forming the tax base is also quite unfavourable (3,523 € in 2022, the average: 4,465 €). The town's environmental situation is significantly degraded by the CO_2 emissions level of operating businesses (20,823,768 tons) and NO_2 emissions (80,218 kg/year), these values being more unfavourable only in the former "socialist city" of Tiszaújváros (CO_2 emissions of 405,487,346 tons, NO_2 emissions of 958,162 kg/year). Regarding the income conditions of the two towns, Tiszaújváros has a significantly higher per capita domestic income (7,601 € in 2022), largely thanks to its chemical plants. The development of Tiszaújváros was essentially based on the Olefin program.[7] Encs and Gönc, as district centres, partly bring together the villages of the Abaúj region and the Zemplén area, with the common characteristic of being centres of disadvantaged regions. Encs is part of the Gönc region, a town without an urban role, located in the Hegyalja wine region. The district seats mentioned above lack industry, as reflected in the number of unemployed (Encs 311 people, Gönc 178 people), as well as in per capita domestic income values (4,097 € in Encs, 3,629 € in Gönc in 2022, with the average being 4,465 €). The group of towns closely linked to Miskolc partly plays a dormitory role, such as Alsózsolca. Sajószentpéter has an industrial function, similarly to Sajóbábony (due to chemical plants), but does not truly fulfil an urban role. There are no outstanding indicators among the social innovation data for these towns, and they only show an average performance.

Cluster D: Cities without a real Urban Role, difficult to live in

The 4th cluster consists of two elements. This group includes Szendrő, the former district seat, which is currently part of the Edelény district. It used to play a significant role before the unification of the counties. The other member of the cluster is Cigánd, which is the centre of Bodrogköz and a district seat.

Szendrő's natural environment is excellent, being located just 39 km (46 minutes) from the county seat, neighbouring the Aggtelek National Park. The number of its educational institutions is mediocre for its size (7 institutions). The number of businesses per 1,000 residents is also 7, with the most significant business in the town being Aluszefém Ltd., which replaced a machine station. The products of Aluszefém Ltd. are mainly used in the automotive, mechanical, construction, and gas industries. The town's CO_2 emissions, measured in tons,

[7] Petrochemical activity began in 1970 with the installation of the first polyethylene plant. Construction of the Tisza Oil Industry Company began in 1973, and oil processing began in 1978. In addition, the 140-hectare Tiszaújváros Industrial Park has been in operation since 1997 (tiszaujvaros.hu).

amount to 1,376,949, which is not considered favourable, while NO_2 emissions are 2,596 kg/year.

Despite being the district seat of Bodrogköz, Cigánd is in a precarious situation due to its demographic, labour market, and social conditions. In Cigánd, only around half of the households have an employed person. Although Cigánd obtained city status, no real urban functions are associated with it, and the town's institutional network is extremely underdeveloped. Larger scale "urban development" is not a realistic option in Bodrogköz in the future.

The two towns in this cluster contribute the two lowest per capita domestic income values for the 28 cities examined. Cigánd's per capita domestic income is 2,884 €, while that of Szendrő is just slightly higher, at 3,047 €. This significantly contributes to the difficult living conditions of the towns' residents. However, for Szendrő, a potential breakthrough point could be the presence of the highest proportion of educational institutions per capita.

Cluster E: Lagging Cities with Unfavourable Conditions

In some cases, it can be assumed that the losers of regime change, the economically disadvantaged mining and industrial towns were granted city status as a form of "consolation", as demonstrated by the example of Rudabánya and Borsodnádasd. The Nádasdi Ironworks, founded in 1864, had a profound impact on the life of the town and its surroundings for over 120 years. The town's settlement structure still reflects the traces of the settlement built around the former factory, with the main square of the settlement being the area in front of the former factory gate. The closure of the factory in 1991 interrupted the development of Borsodnádasd. Small businesses sprang up on the ruins of the factory, but they were not significant. Since the closure of the steel mill, the central location of the settlement has almost completely disappeared, replaced by a more rural image, and the factory district now functions mainly as a dormitory area with no real "town-village" role.

The CO_2 emissions from the small factories built on the site of the steel mill amount to 20,014 tons, and the NO_2 emissions are 178 kg/year, which is not considered significant. The town's aging index is 48%, which is very high, and naturally, the proportion of job seekers within 180 days is relatively low. In 2022, Borsodnádasd had one of the lowest per capita domestic income values among the 28 cities of Borsod-Abaúj-Zemplén County, with 3,127€. Additionally, the town ranks last in terms of the proportion of individual entrepreneurs. The liveability of the town is significantly impacted by the fact that it has only one educational institution, and the number of cultural institutions is only slightly higher (2), with one museum (the Local History Museum). The only attractive feature is the picturesque surroundings of the area.

SUMMARY

In our study, we attempted to assess the economic and environmental sustainability of the cities in Borsod-Abaúj-Zemplén County using the SDG methodology and indicator set developed by the UN, focusing on three main dimensions. Our attempt to measure sustainability was based on an analysis of the cities in the county divided into five clusters, which resulted in more or less homogeneous groups in terms of the structure of the cities in the county. The methodology developed for the analysis is suitable for measuring both sustainable development goals and social innovation through the analysis of goals 8, 9, and 11 (Goal 8: Decent Work and Economic Growth, Goal 9: Industry, Innovation, and Infrastructure, and Goal 11: Sustainable Cities and Communities). The resulting composite indices also confirm the findings of previous research on settlement networks (e.g., Beluszky & Sikos T., 2020), clearly distinguishing between real urban groups and "created" cities (similarly to the analysis of Szirmai (2013), which also analyzed the socialist planned cities (with extensive industrial development and powerful ideological roles) from the county, such as Kazincbarcika or Tiszaújváros.

Based on the indicators examined, among the municipalities closely connected to the Miskolc agglomeration, the small towns of Nyékládháza and Tokaj possess compact urban characteristics. Among the cities in Borsod-Abaúj-Zemplén County, the medium and small towns, as well as those connected to the Miskolc agglomeration, are considered dynamic and liveable in the region. These towns may have the potential for breaking out of their peripheral positions within the county. The indicators measuring social innovation also reflect the outstanding performance of the first cluster, while the group of "cities searching for their place, offering below-average living conditions" shows an average performance based on these indicators. In the case of the declining Borsodnádasd, individual businesses do not represent a realistic point of breakthrough.

The biggest limitation of the applied methodology is that there is significantly less data available at the meso level compared to, for example, the analysis of cities with county rights. It limits the generalizability of the results and the specificity of indicators for measuring social innovation potential, such as in the case of measuring smart cities mentioned by Dusek (2024). Another limitation is that according to the model's methodology, cities with extreme values may have differential effects on the composite indicator in each region, potentially distorting certain elements and causing autocorrelation between the indicators. These factors should definitely be monitored when applying the model. Regarding the opportunities for international comparisons, the database also has some shortcomings, as our data was gathered mainly from national databases which do not allow for applying a similar structure and set of indicators for the Visegrad countries. Thus, in international comparisons, only the methodology can be smoothly transferred to practical analyses. However, from a spatial development perspective, the relevance of sustainable social innovation is unquestionable, as it can significantly contribute to the catching up of settlements in peripheral situations.

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