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Have Hungarian districts become more resilient? – A comparison of the 2014 and 2020 Baseline Resilience Indicators for Communities (BRICs)

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Abstract
Recent crises have put resilience at the center of sustainability and territorial studies. Enhancing resilience plays a crucial role in sustainable regional development and calls for knowledge of local vulnerabilities as well as capacity for absorption, adaptation, and transformation. Community resilience refers to the ability of different regional levels to adjust their socioeconomic systems to manage the adverse effects of shocks and stresses and to be able to provide adaptive responses. So far, studies have focused mainly on specific areas, which is difficult to apply in the context of successive crises and makes it more challenging to set development priorities.
This research adopts the Baseline Resilience Indicators for Communities (BRIC) framework and focuses on changes between 2014 and 2020. The community resilience assessment of Hungarian districts revealed quite a homogenous performance concerning the overall score but showed high heterogeneity concerning the five resilience dimensions evaluated. Over time, the indicators generally increased in the social and economic domains and decreased in the community domain. Besides, rapid suburbanization processes around cities contributed to lower overall performances indicating the necessity of action.

Keywords: community resilience, BRIC, regional pattern, Hungary, spatiotemporal analysis

1. Introduction

The frequency of past major worldwide disasters has increased over time, leading to the proliferation of resilience both in academia and policy debate. Extreme weather events have already resulted in record-breaking levels of fatalities and property damages (Sung & Liaw, 2020). The cardinality and severity of recent crises (such as the COVID-19 pandemic, geopolitical shocks, energy instability, decline in biodiversity and climate change) imply that contemporary societies are frequently inadequately prepared for natural and human-induced disasters (De Iuliis et al., 2022). It became apparent that business as usual practices are not feasible in future instead, boosting resilience is inevitable in mitigating the effects of disasters (Cutter, 2016). Resilience is still an emerging research area where the applied concept and approach change over time as new knowledge becomes accessible with every disaster (Gerges et al., 2023). The term resilience derives from the Latin *'resilire'* bouncing back. Resilience entered the scientific discussion in the 1960s in the field of ecology and has since gained a foothold in psychology, disaster management, system-thinking, and engineering, followed by urban planning and social sciences (Moloney & Doyon, 2021). Despite the numerosity of resilience interpretations offered, shared elements can be identified, such as the metaphor of "rebounding" or "returning"

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to a fresh state of "non-dynamic equilibrium" (Brunetta et al., 2019).

The notion of community resilience is founded on urban resilience, acknowledging that changes take place at a more precise geographical scale (Liu et al., 2022). At the community level, studies emphasize psychological aspects, culture, awareness, and conscientiousness that determine the capacities of people, families, and communities from a social perspective (Cutter, 2016). Community resilience is frequently defined as the capacity of various communities/regional levels to modify their socioeconomic systems to counteract the negative impacts of shocks and stresses and to be able to offer adaptive solutions (Scherzer et al., 2019). The absorptive capacity of the system accounts for withstanding the disturbances (including stability and recoverability), while adaptive capacity refers to learning from and adjusting to changes brought on by disruptions (Cutter, 2016). Studies that assess community resilience or apply a disaster resilience approach tend to focus on these two abilities, however, resilience is characterized by transformative capacities as well, relating to significant, nonlinear improvements to address many hazards (Brunetta et al., 2019). Drawing on society's capabilities and taking proactive measures can improve the afflicted areas' ability to prepare for, respond to, and recover from the adverse effects (Scherzer et al., 2019). However, building resilience at regional or community scale can often be characterized by point measures, such as constructing a barrier, elevating the power generator of a plant, and creating flood mitigation measures. In addition, decision-makers must prioritize these disconnected interventions answering a challenging resource-allocation dilemma considering both financial and non-financial aspects (Gerges et al., 2023). Prioritization is further hampered by the lack of comprehensive territorial studies, as studies have so far more focused on specific (for instance economic or climatic) resilience.

Since improving community resilience is often tied to local characteristics and endogenous resources, resilience and place-based approaches go hand in hand. A territorial perspective can effectively address both the physical resources (such as community facilities) and perceptual resources of individuals, both of which are essential in the promotion of resilience (Shapira, 2022). Territorial assessment of (community) resilience suited for analyzing regional variability, resource allocation, and/or progress tracking on different scales and levels (Cutter, 2016). Brunetta et al. argue that evaluating resilience as a complex process calls for the use of a multi-criteria approach. This comprehensive interpretation relies on three underlying premises: (1) a multidisciplinary perspective; (2) considering the cultural and community dimension; and (3) recognizing the phasing of time. This requires downscaling and adjusting current frameworks to give a territorial assessment of resilience and propose local actions, policies and strategies (Brunetta et al., 2019).

Community resilience assessment tools make resilience a more tangible, understandable, and measurable concept by exploring several aspects of a community connected to resilience (Asadzadeh et al., 2017). The goal of community resilience assessment is to put the idea into practice and offer a method for navigating the complexity of community systems while calculating their resilience (De Iuliis et al., 2022). Quantitative and qualitative assessments are essential for comprehending resilience and guiding planning decisions (Brunetta et al., 2019). Reflecting the multi-disciplinary essence of resilience, different research teams have used various theoretical approaches to measure community resilience (Tariq et al., 2021). As a result, there is no general agreement on the method to be applied

(Cutter, 2016; De Iuliis et al., 2022). Recent research has shown that a composite assessment that takes into account aspects of human health, well-being, and social, economic, and ecological resilience is beneficial (Saravanan & Garren, 2021). Along this line, instead of developing another set of indicators for assessing community resilience, this study joined the already existing, and internationally recognized Baseline Resilience Indicators for Communities framework introduced by Cutter et al. (2010, 2014) and implemented it into the Hungarian context.

BRIC is one of the first indices to assess community resiliency to catastrophes (Gerges et al., 2023). The BRIC framework was developed based on the theoretical underpinnings of the disaster resilience of place (DROP) model. This tool interprets resilience as a bouncing-forward cycle (Sung & Liaw, 2020) and employs a range of pre-disaster characteristics of the community to determine how robust it would be under unfavorable situations (Gerges et al., 2023). The framework takes into consideration every essential aspect outlined in research on community resilience and has great coverage of disaster resilience characteristics (Asadzadeh et al., 2017; Sharifi, 2016). In addition, Asadzadeh et al. (2017) comparing and qualitatively assessing 17 resilience metrics found that Cutter et al.'s (2014) resilience index is theoretically comprehensive, and strong in terms of validation and understandable, legible, and interpretable results. However, it's a non-participatory, deductive approach which involves an evident subjectivity. The first BRIC studies were conducted in 2010 by Cutter et al., and since then the indicator system has been developed and applied to local specificities by several scholars. Cutter et al. (2014) presented an improved indicator version of BRIC for American counties and included an environmental domain besides social, infrastructural, economic, institutional and community dimensions. Singh-Peterson et al. (2014) applied the framework for the Sunshine Coast local government area in Australia with only slight modifications owing to the similarities in available data. Recent studies have adapted the framework to assess community resilience in Norwegian municipalities (Scherzer et al., 2019), Iranian provinces (Javadpoor et al., 2021), the Mill River Watershed (USA) (Saravanan & Garren, 2021), Yilan County (Taiwan) (Sung & Liaw, 2020), and Hungarian districts (Csizovszky & Buzási, 2023). These studies place greater emphasis on the features and attributes to be captured, as opposed to the adoption of the same variables. The index's objective is to provide a set of standards and parameters that can be used to compare resilience at the county or district level (Gerges et al., 2023). However, the existing BRIC studies only attempted to explore spatial correlations/differences without attempting a comparison over time. Even considering broader assessment tools, there are very few comprehensive community resilience studies that consider multiple time states. To fulfill this gap, the present study employs a spatiotemporal focus and compares the community resilience of Hungarian districts in 2014 and 2020.

Research on resilience in Hungary is currently at an early stage. Within the academic context, besides research on economic resilience and climate adaptation, the field of urban resilience is considered to be better represented, while community or spatial resilience research has been neglected so far. From a practical point of view, some methods of disaster resilience have been part of national thinking for a longer time, for example, protocols exist for effective protection against heat waves or floods led by disaster management. In addition, climate change resilience has been introduced into public thinking and spatial planning, and local climate strategies can be found since the early 2010s. However, more general resilience strategies are only now beginning to take shape in Hungary in response to EU expectations and various recent crises. The first representatives of this process are the Sustainable Urban Development Strategies - designed after 2020 – which involve several dimensions of resilience. Reinforcing planning with research is essential. When planning and making decisions, policymakers may give more attention to the highlighted shortcomings in areas that lack resources, assets, or capacities (Javadpoor et al., 2021). The present study builds on the results of our previous research currently going through the publication process. Our previous work (Csizovszky & Buzási, 2023) established the BRIC measurement for Hungarian districts, and its statistical foundation, however, did not pay any attention to spatiotemporal changes. To remedy this, we have extended the analysis over time based on the availability of indicators and compared two periods (2014 and 2020) to explore the spatial evolution of local community resilience. The BRIC assessment embedded in Hungarian context relies on 33 indicators divided into five dimensions (social, economic, community, infrastructure, and environmental). As stated before, indicators of community resilience can reveal information about society's capacity to survive or adapt in the face of crises. The findings should make a meaningful contribution to understanding of trends in community resilience and answer the question: Have Hungarian districts become more resilient? Moreover, it is hoped that the results can be used in the strategic planning processes that are currently being developed, thus supporting decision-makers in setting priorities.

2. Community resilience index for Hungary

The design of the Community resilience index was based on the BRIC framework, the work of Cutter et al. (2010, 2014) and its subsequent applications (Javadpoor et al., 2021; Opach et al., 2020; Saravanan & Garren, 2021; Scherzer et al., 2019; Singh-Peterson et al., 2014; Sung & Liaw, 2020). When embedding the framework in the Hungarian context, we kept in mind the specific characteristics to be captured and chose the most appropriate ones from the existing data of the Central Statistical Office (KSH). First, we developed the indicator system for 2020 and validated it with statistical methods, which can be found in a previous article currently under publication. Subsequently, the extensibility over time was examined, which required minor modifications due to changes in data collection and availability. In the final set of indicators, which allows for comparison over time, a total of 33 indicators, divided into 5 dimensions, serve to measure community resilience in Hungary. Only publicly available data were used in the analysis, sourced from the Central Statistical Office (KSH) and the National Regional Development and Spatial Planning Information System (TeIR). Data were retrieved and calculated at district level.

A brief summary of the critical attributes to be captured by dimension is provided here, while a detailed description of the indicators is presented in Table 1, including the direction of the impact on community resilience. The social subdomain reflects the physical and mental wellbeing of society including demographic attributes as well as access to communication, vehicles, and healthcare services (Cutter et al., 2010, 2014). The former is important hence for example elderlies, children, disabled persons are assumed to be less resilient due to dependency on others (Scherzer et al., 2019). The significance of the latter

Table 1: Indicators for community resilience in Hungary

Dimension	Indicator	Effect on resilience	Source	2014 Mean	2014 Min	2014 Max	2020 Mean	2020 Min	2020 Max
Social									
S1	Working age (proportion of population aged 15-64 years)	+	KSH	67,2 [a]	62,5 [a]	70,9 [a]	65,0	60,5	69,2
S2	Migration balance per 1000 capita	+	KSH	-2,79	-16,2	13,64	1,30	-17,3	44,39
S3	Natural growth rate	+	KSH	-4,42	-16,2	4,48	-5,74	-16,0	5,35
S4	Number of marriages per 1000 capita	+	KSH	3,54	1,96	5,19	7,00	5,11	9,10
S5	Number of residents per GPs and pediatricians	-	KSH	1617	1128	2367	1745	975	2694
S6	Cars per 1000 capita	+	KSH	298,8	189,1	514,5	393,2	268,6	638,2
S7	Internet subscriptions per apartment	+	KSH	0,49	0,30	0,81	0,65	0,33	1,03
Economic									
Ec1	Registered jobseekers per 1000 persons aged 15-64 years	-	KSH	65,0 [a]	7,7 [a]	154,2 [a]	60,8	9,7	157,4
Ec2	Proportion of microenterprises in active enterprises	-	KSH	95,2	91,6	97,1	91,9	87,9	94,3
Ec3	Enterprises having at least 50 employees per 1000 capita	+	KSH	0,82	0,00	2,42	0,82	0,00	3,29
Ec4	Number of branch banks per 1000 capita	+	KSH	0,18	0,00	0,82	0,11	0,00	0,31
Ec5	Personal income taxable income (1000 HUF) per taxpayer	+	TeIR	1984	1438	3409	2943	1931	4738
Ec6	Number of civic organizations per 1000 capita	+	KSH	5,18	2,68	10,88	5,27	2,57	9,51
Community									
C1	Places in infant nurseries (per 1000 persons aged 0-2 years)	+	KSH	94	0	256	129	0	330
C2	Schools (per 1000 capita)	+	KSH	0,46	0,17	0,96	0,46	0,16	0,85
C3	Number of family and child welfare services (per 100 000 capita)	+	KSH	9,59	0,92	37,82	10,91	1,19	40,43
C4	Total number of persons employed in basic social services and day care (per 1000 capita)	+	KSH	3,46	0,57	23,76	3,22	0,40	27,30
C5	Proportion of settlements providing day care for the aged	+	KSH	43	2	100	31	0	100
C6	Area of playgrounds, athletic grounds and resting places (m^2 per capita)	+	KSH	1,45	0,00	10,97	1,27	0,01	10,77
C7	Number of cultural events per 1000 capita	+	KSH	20,77	4,85	78,22	8,19	1,41	45,18
Infrastructure									
I1	Number of dwellings ceased due to obsolescence or natural disasters per 1000 apartment in the previous five years	-	KSH	0,37	0,00	8,42	0,28	0,00	1,31
I2	Proportion of dwellings connected to public water conduit network	+	KSH	0,93	0,60	1,00	0,93	0,59	1,00
I3	Proportion of dwellings connected to public sewerage network	+	KSH	0,65	0,04	0,96	0,73	0,21	0,97
I4	Length of public roads (km per 1000 capita)	+	KSH	7,27	2,48	14,38	7,78	2,70	14,99
I5	Number of railway stations (per 1000 capita)	+	KSH	0,16	0,00	0,78	0,16	0,00	0,81
I6	Time to reach the nearest city of at least 100,000 inhabitants by the fastest road (min)	-	TeIR	62	0	169	63 [b]	0 [b]	157 [b]
I7	Number of pharmacies (per 1000 capita)	+	KSH	0,34	0,12	0,52	0,34	0,14	0,58
I8	Number of fire protection units (per 1000 capita)	+	TeIR	0,02 [a]	0,00 [a]	0,10 [a]	0,03 [b]	0,00 [b]	0,10 [b]
Environmental									
En1	Local government owned green areas, total (m^2 per capita)	+	KSH	17,4	0,4	76,4	29,9	1,6	602,1
En2	Water consumption (m^3 per capita)	-	KSH	36	19	68	41	22	88
En3	Energy consumption (kWh per capita)	-	KSH	3145	1085	18348	3528	1253	22716
En4	Proportion of built-up areas (Corine 11, 12, 13)	-	TeIR	0,07 [c]	0,02 [c]	0,63 [c]	0,07 [d]	0,02 [d]	0,63 [d]
En5	Proportion of natural areas (Corine 31, 32, 41, 42, 51)	+	TeIR	0,30 [c]	0,02 [c]	0,73 [c]	0,30 [d]	0,02 [d]	0,73 [d]

where difference in year of data a) 2015; b) 2019; c) 2012; d) 2018 component is associated with general physical and mental health, emergency response and access to information. The economic dimension reflects the vitality, stability and diversity of the economy (Opach et al., 2020), as well as access to financial resources (Burton, 2014). The key variables are income, business size, unemployment, civic organizations. This subdomain refers to the characteristics of the whole economy, rather than of individual businesses (Scherzer et al., 2019). The community subdomain describes possible connections among citizens and their environment (Cutter et al., 2010), including active social life that enables the creation of informal safety network, and the formal safety networks provided by social services. Thus, even if it may indicate that there are more individuals in need, the larger rate of social services was considered beneficial. The key characteristics of infrastructure from community resilience aspect are the quality of housing and the critical infrastructure for evacuation and supply (Scherzer et al., 2019). The environmental dimension accounts for nature's absorptive capacity and the efficient resource use of the community. Absorptive capacities provide the basis for short-term responses, while the second attribute is relevant for long-term stresses (Saravanan & Garren, 2021). Finally, like Javadpoor et al. (2021), no institutional dimension was distinguished due to the lack of data on crisis management, although the role of formal safety nets and organizations is part of the community and infrastructure subdomains. Due to inconsistencies in data collection over time, 3 indicators were excluded from the previously presented (Csizovszky & Buzási, 2023) indicator set and *C7* was slightly modified.

To perform comparisons and operations, indicators with different units of measurement need to be normalized. Maintaining the original distribution of the data is crucial in the analysis of differences, hence min-max normalization has been applied (using formula 1 when the variable is positive and formula 2 when the variable is negative) to transform the variable values between 0 and 1. In addition, price changes can affect the variables of the index system. To make the time series comparable, the 2014 variables have been adjusted for inflation between 2014 and 2020 (based on data from the CSO). This was only necessary in one case, for the *Ec5* indicator. When determining the values of the dimensions (Social, Economic, Community, Infrastructural, and Environmental), each indicator was given the same weight. The scores of the dimensions for each year are the average of the normalized values of the indicators in that dimension for that year. The Overall Community Resilience score was calculated by averaging the dimensions equally for each year. The QGIS 2.28 software was applied to plot the spatial distribution of the scores per dimension and the overall score. The appropriate representation was chosen from several options in order to show both the spatial patterns in each year and the change between years. Finally, the equal intervals method and 7 categories were selected, which reflected the natural breaks per year reasonably well.

$$X_{ij}^{*} = 1 - \frac{max(X_j) - X_{ij}}{max(X_j) - min(X_j)} \tag{1}$$

$$X_{ij}^{*} = \frac{max(X_j) - X_{ij}}{max(X_j) - min(X_j)} \tag{2}$$

where X_{ij} represents the *i*th sample of the *j*th variable; $min(X_j)$ is the minimum value of the *j*th variable for the two years under study; $max(X_j)$ is the maximum value of the *j*th variable for the two years under study; and X_{ij}^* is the standardized value of X_{ij}.

3. Spatial and temporal analysis

The aim of the study is to measure the Hungarian community resilience and to examine its spatial distribution and its evolution over time. Figure 1 shows the 2014 and 2020 values for the districts by dimension. In this chapter, we will first look at the spatial aspects and their evolution by dimension, followed by the change in the overall value (see Figure 2) and general findings.

The **social** domain shows a difference between the western and eastern parts of the country. Higher values are particularly prevalent in the North-West, the capital, and its surroundings in both years. There was a general improvement in the social indicators over the period, with an increase in all districts. The improvement was significant in the area around Lake Balaton, in the eastern agglomeration of Budapest, and in the districts of Debrecen and Nyíregyháza, which were among the top performers in the social dimension by 2020. A very similar pattern is observed for the **economic** dimension, with better performance in the North-West and around the capital. Economic community resilience scores increased everywhere but a few districts between 2014 and 2020. At the same time, the spatial distribution remained almost unchanged. The most interesting and surprising developments occurred in the **community** dimension during the period of the study. In 2014, the East-West differences are most striking, with the East performing better overall. Thus, a significantly different pattern emerged for this dimension compared to the previous two. This is due to a better developed formal safety net, which has been associated with less favorable socio-economic conditions. By 2020, the community score had decreased in the majority of districts (two thirds) and increased in about one third. As a consequence, the spatial pattern has changed significantly. Although some east-west differences can be observed in year 2020, the larger differences are between urban areas and other areas. The values of the community dimension have deteriorated in the agglomeration areas.

Infrastructural change is essentially a slower process, which is reflected in the small changes that have taken place in the study period. From a territorial point of view, two main groups can be distinguished: rapidly agglomerating districts and the less well integrated, more backward districts. In the **environmental** dimension, in addition to the outstandingly poor performance of the capital city in particular, a generally poorer performance is observed in the districts with higher industrial activity and in the neighborhoods of larger towns. These indicators reveal the areas of the Great Plain and the Little Plain, which appear mostly with medium values on the maps. These two groups of intermediate values expanded between 2014 and 2020, consistent with the transformation of the areas due to climate change and their declining natural capacity. Besides, only a slight change was observed in this dimension, with a negative trend for most districts which can be explained by the increase in consumption (*En2* and *En3*).

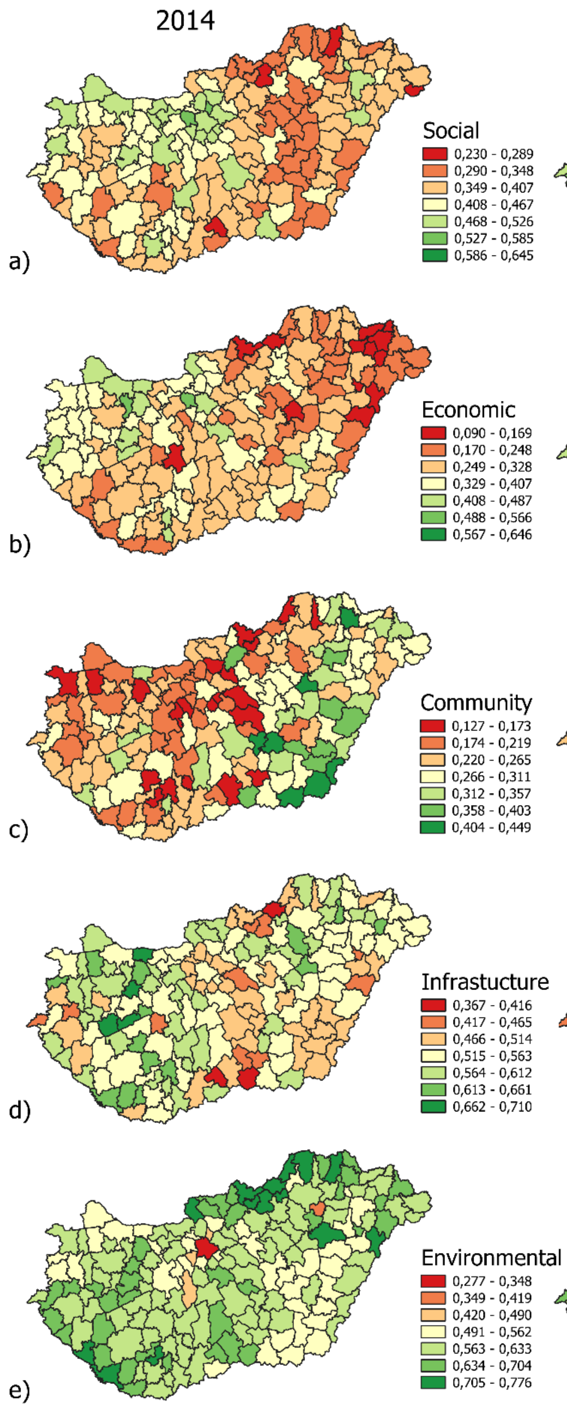

Figure 1. Community resilience of Hungarian districts in 2014 and 2020 by a) social; b) economic; c) community; d) infrastructure; e) environmental) dimensions

The overall resilience score of the community shows a relatively homogeneous picture for both years. Basically, a greater difference appears between the eastern and western parts of the country, with the western, and more specifically the north-western, areas performing better. Between the two periods, with the exception of 4 districts, all districts showed an increase. However, the spatial patterns barely changed. In 2020, the North-Balaton areas had the outstandingly good performance.

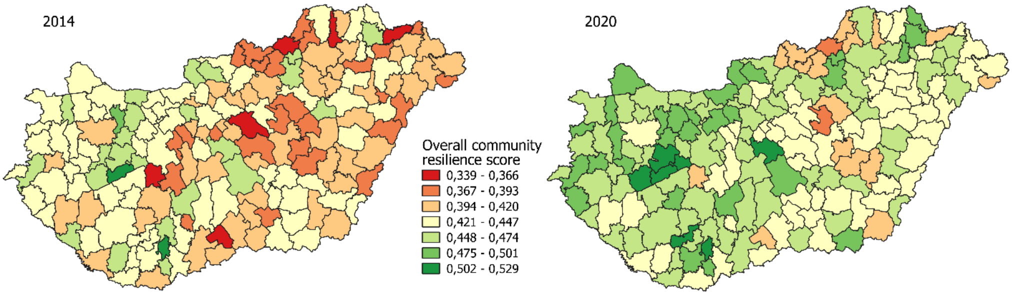

Figure 2. Overall values of Community Resilience Index in 2014 and 2020

It is apparent from Figure 3 that the overall growth can be explained by an increase in the values of the social and economic subdomain, with a smaller share of infrastructure development. The value of the community dimension has basically decreased and to a greater extent than the environmental dimension. However, in almost all cases, the decrease was outweighed by the development of socio-economic characteristics, so that the overall community resilience value also showed an increase.

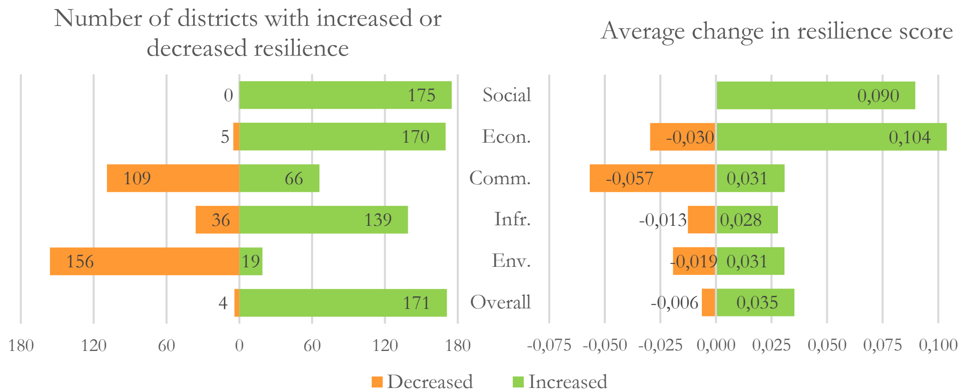

Figure 3. Evolution of community resilience between 2014 and 2020

The strong growth in social indicators is driven by a prominent increase in 3 indicators: the number of cars, internet subscriptions and marriages. Marriages have risen 2-3 times, which is the realization of the government's political will, even though in 2020 strict epidemiological restrictions have been imposed on the holding of weddings. The recorded growth significantly exceeds and thus masks the negative social trends observed over the period, such as the slight decline in the working-age population and natural reproduction, as well as a modest increase in the medical workload. The boost in the economic subdomain is due to the enlargement in incomes (adjusted for inflation), the decrease in the number of job seekers and the ratio of micro-enterprises. Despite the overall decrease in the community dimension, the number of places in nurseries has generally increased. Indicators *C2, C3*, and *C4* show minor changes in different directions, while recreational spaces per population decreased, as did home help services. The decline in the role of home help can be surprising in an ageing society like Hungary. The period studied has been characterized by several changes in the legal environment for eldercare while, as the indicators show, there has been no adequate response to date. The most significant shrinkage was in the number of cultural programs, which is not a consequence of a trend, but a sudden decline caused by the COVID-19 epidemic. If we remove the *C7* indicator, the reason behind the significant drop, then a putative increase can be observed. However, further insight reveals a significant decrease in several districts, compared to a modest increase on average for most districts. In addition, the values are much lower in both years than for the other dimensions, suggesting that there are 1 or 2 outperforming districts in each indicator, while most districts are lagging behind them. As regards the infrastructural aspects of community resilience, there is no outstanding explanatory power for the direction and magnitude of change, but it comes from the aggregation of effects. For many districts, the main drivers of growth are the expansion of public sewerage and drinking water networks over the period. Finally, in terms of environmental aspects, the land use indicators (*En4, En5*) hardly changed, and the overall slight decrease in this dimension is due to an increase in water and energy consumption (*En2, En3*). The trends also have a domestic policy context, with no increase in service charges during the study period resulting from the reduction in residential utility bills introduced in 2013. In other words, the role of prices as a demand restraint failed to materialize, which later caused significant problems for both residential and institutional actors in the escalation of the energy crisis, as there was no (or limited) investment in energy efficiency. Growth in the environmental dimension, where seen, is primarily the result of an increase in local government-owned green areas (*En1*). The increase in the *En1* indicator does not necessarily mean an increase in green spaces in absolute terms but can also be the result of administrative reasons, i.e., more green areas (such as forests) are taken under the management of the municipality, which leads to anomalies.

4. Conclusion

The present study was designed to determine whether Hungarian districts become more resilient. Spatiotemporal change between 2014 and 2020 was examined using a community resilience perspective to provide an answer. The BRIC framework, previously adapted for Hungarian districts, presented the inevitably context-specific tool and provided the starting point. However, it required a slight modification to allow for comparability over time. The indicators can support the identification of strengths and shortcomings of the community's capacities, thus, can underpin policy responses to enhance resilience. Previous studies have generally failed to make comparisons over time, despite the substantial added value for decision-makers. Analyzing the patterns from a broader viewpoint and considering trends is crucial to determine the present state of development.

In general, the overall resilience of the districts has increased almost without exception. The values for the social and economic subdomain reflect remarkable progress, implying an improvement in the overall socio-economic conditions. Infrastructure indicators show little progress reflecting the slow evolution of the built environment. At the same time, when considering the values by dimension, there was a slight decrease in the environmental and a more significant decrease in the community dimension. Behind the declining capacities lies an overall increase in consumption and a lack of development of formal and informal safety nets. The findings also reflect the worsening of the ageing social structure and the inadequate preparation. These trends identify areas for improvement. However, in the environmental dimension, although fundamentally linked to them, natural disasters are not included in the index (due to measurement difficulties and lack of data). In other words, the results for the environmental dimension cannot be considered as complete or comprehensive, but rather as a reflection of used resources and available capacities.

From a territorial perspective, the results show a slight narrowing of the gap between the eastern and western parts of the country and metropolitan areas are becoming more dominant and prominent. This shift could even provide a direction for national territorial thinking. The economic score remains the highest in the northwestern part of the region. The social subdomain showed the most improvement in the larger cities, particularly in their metropolitan areas, often accompanied by a more marked deterioration in the community dimension. In addition, socioeconomic development was accompanied by an increase in consumption. Balanced development is an essential issue in terms of both sustainability and resilience which requires coordination in building capacities and helps avoid maladaptive solutions. Furthermore, strengthening territorial strategic planning would also benefit from integrating resilience capacities, complemented by planning for uncertainty.

This study contributes to the existing literature on resilience in Hungary by presenting the first spatial analysis of community resilience in this context. Prior research has mainly focused on urban areas and heat wave conditions, leaving a knowledge gap regarding community-level resilience assessment. Among the urban adaptation studies, Szép et al.'s (2021) and Nagy et al.'s (2022) work aligned with our findings in the social, economic, and environmental dimensions. However, their complex resilience index highlighted the prominence of the Budapest agglomeration, which differs from our analysis due to the emphasis on sustainability issues in infrastructure and community considerations. Another study (Buzási et al., 2022) investigated sustainability and heatwave vulnerability of county seat cities using fuzzy logic. While there were similarities in terms of sustainability, their focus on specific exposures to heatwaves was not incorporated into this Community Resilience Index, leading to partial alignment with the results. Uzzoli et al.'s (2019) research utilized general socio-economic and development indicators for sensitivity and adaptive capacity to heatwaves, revealing comparable outcomes in terms of east-west and rural-urban differences, which harmonize with our social and economic dimensions. In summary, this study complements existing literature by introducing a novel community resilience perspective, enriching disaster-related considerations not previously addressed in Hungarian studies, which primarily centered on urban areas and heatwave conditions.

The comprehensive spatial evaluation of community resilience presented here can serve as a valuable foundation for future research and inform more effective resilience-building strategies across Hungary.

Being limited to quantitative indicators, this study lacks qualitative research and validation of the results, which would be a fruitful area for further work. In addition, the institutional dimension was excluded from the investigation due to the unavailability of data. However, government responses are decisive aspects of community resilience and can be essential in shock-type crisis management. Access to data from the National Directorate General for Disaster Management of Hungary would help to assess the institutional dimension and could also be used to judge the validity of the results. Therefore, it would greatly benefit the improvement of the community resilience index.

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