NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Bulletin of Geography. Socio-economic Series, No. 70 (2025): 67-84
http://doi.org/10.12775/bgss-2025-0039

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES

journal homepages:
https://apcz.umk.pl/BGSS/index
https://www.bulletinofgeography.umk.pl/

A multi-aspect decision-making approach, for regional developments based on Hungarian natural-healing factors

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How to cite:
Szabó, Z., Hojcska, A.E., & Bujdosó, Z. (2025). A multi-aspect decision-making approach, for regional developments based on Hungarian natural-healing factors. *Bulletin of Geography. Socio-economic Series*, 70(70): 67-84. DOI: http://doi.org/10.12775/bgss-2025-0039

Abstract. The study aims to support the development of a modern, scientifically grounded, and practically applicable decision-preparation system designed for managerial use in the decision-making processes related to regional development based on natural-healing factors. The system is developed through the extensive application of a systems approach. The analysis of territorial polarisation measurement employs indicators such as the extent-ratio, extent of dispersion, relative extent, and the dual indicator (Éltető–Frigyes index). Territorial distributions are examined using the Gini index, the Hirschman–Herfindahl index, and the Hoover index. Based on the obtained results, a decision-making system for regional development grounded in natural-medicine factors is constructed, incorporating various indicators and cartographic representations. Within the framework of the systems approach, the key components include the medicinal healing factors inequality index, variability index, concentration index, and territorial distribution index. The system also integrates maps that enable regional comparisons and serve as planning and decision-support tools across all hierarchical managerial levels.

Article details:
Received: 30 April 2025
Revised: 08 October 2025
Accepted: 14 November 2025

Key words:
geography, planning & development, Gini index, management, natural-healing factor, territorial indices, Hungary

Contents:

1. Introduction

The relevance of our research is that managers encounter a plethora of data related to Hungarian natural-healing factors, so it has become necessary to compress information and provide content that helps them in decision preparation. Groundwater in the Carpathian Basin, including Hungary, occurs in three types of aquifers (Gáspár, 2009; Horváth et al., 2015; Kun et al., 2020). The most widespread type is the porous aquifer, which contains stratified water (pore water) and is most typical of Quaternary and Pannonian-age formations. The next type of aquifer is the fissured aquifer, which forms in rocks with fractures (volcanic, igneous rocks – i.e., granite, basalt, etc.). The karstic aquifer type, which is of great importance and extent, is typical of karstic formations (limestone, dolomite). Fractures form when formations are brought to the surface or close to it and are released by water seeping below the surface, even creating cavity systems with enormous water storage capacity.

The reservoir systems also differ in terms of recharge, with (mesosaline) carbonate reservoirs located in the intensive flow zone and having recharge, and porous reservoirs having a more static recharge and only a small recharge.

Hungary, due to its location in the Pannonian Basin, has favourable geothermal potential, with a geothermal gradient of ~5 °C/100 m (50 °C/km), which is about 1.5 times higher than the world average (~2–3.3 °C/100 m) (Szilágyi & Clement, 2010; Nádor & Lenkey, 2024). This high value is mainly due to two geological features. On the other hand, the basin is filled with a large (average 2.5 km to 6 km) thickness of well-insulated formations and sediments (clay, sand, etc.). As a result of these favourable conditions, the average heat flux density of the Pannonian basin (80–100 mW/m2) is significantly higher than that of the surrounding mountains (European average 60 mW/m2) (Gáspár, 2009; Rman et al., 2020) (Fig. 1).

The location of Hungary's groundwater resources and natural-healing factors can be analysed not only at the geological level, but also at the regional level.

The EU territorial classification system, the Nomenclature of Territorial Units for Statistics (NUTS), distinguishes five levels. As a result of globalisation, the regional level (NUTS 2) is becoming increasingly important as the basic unit of territorial organ-

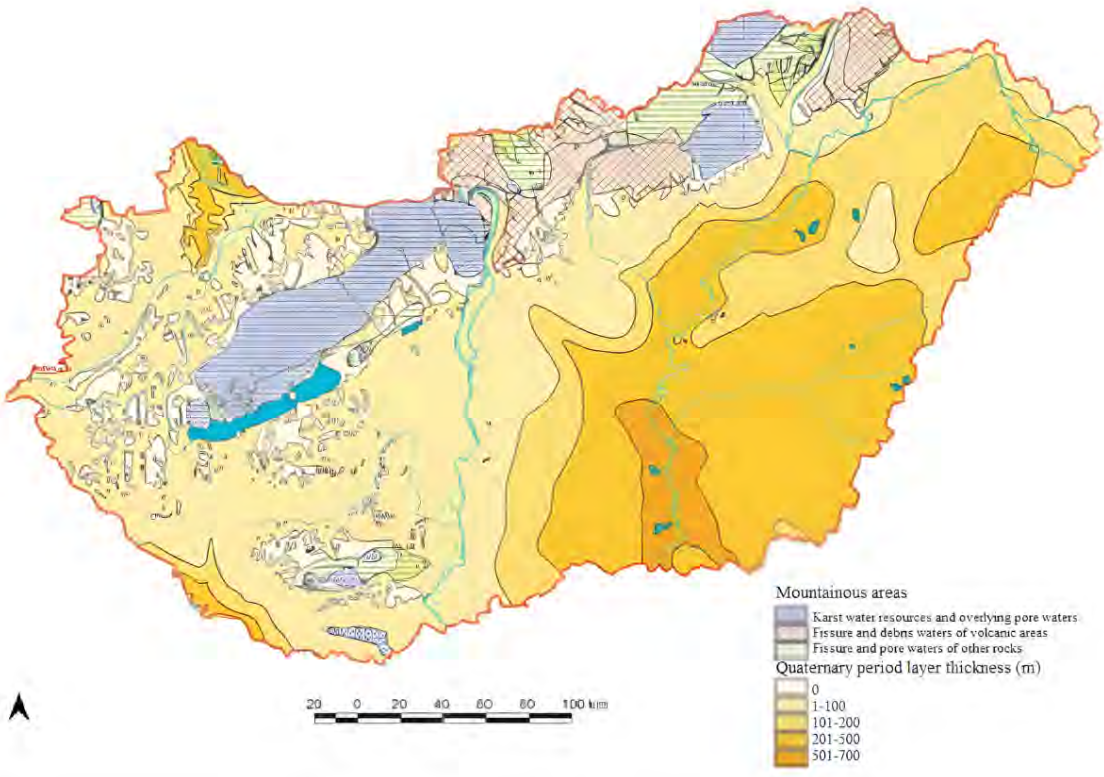

Fig. 1. Location of groundwater aquifers in Hungary (without thermal water reservoirs)
Source: Liebe, 2002; Liebe, 2006

isation due to the relative decline of the national level (NUTS 1) and the relative decline of countries' autonomy (Casellas & Galley, 1999). In Hungary, in preparation for EU accession in 2004, it was an important task to define a territorial system that would correspond to the EU's five-level territorial classification system. In accordance with the EU's territorial classification practice, Hungary currently has three parts of the country (NUTS 1) and eight regions (NUTS 2) within these. Hungary is divided into Central Hungary, Transdanubia, and Great Plain and North. The regions of Hungary are the Western Transdanubia region, the Central Transdanubia region, the Southern Transdanubia region, the Northern Hungary region, the Northern Great Plain region, the Southern Great Plain region, the Pest region and the Budapest region (European Union, 2022). Hungary has historically experienced significant disparities in the development of its regions, which have increased in recent decades (Farkas, 2021). Nowadays, Hungary is divided into regions with different levels of development, because each region has different endowments, so each region essentially develops through inequalities (Dobó & Pintér, 2022). Today, the topic of regional inequalities is topical in Hungary, specifically in classical disciplines such as economic geography, regional science and development economics (Jovic & Popovic, 2006; Lengyel & Kotosz, 2018; Vida & Dudás, 2017). Tourism, which is located at the interface of these disciplines and has a significant potential for economic growth, is gradually growing, and therefore regional research should take into account its regional disparities when planning sustainable development (Bjeljac & Ćurčić, 2006; Stanciulescu & Molnar, 2018; Baloch et al., 2023). Since, in Hungary, tourism is mainly based on thermal-medicinal bath tourism, which is highly dependent on wider environmental factors, exploring these is essential today.

The natural assets of the different regions can be used in many ways. One of the most prominent of these is the use of natural-healing factors in thermal-medicinal bath tourism, including medicinal water therapy.

The healing effects of natural factors (energies) (sunlight, water, air, earth) have been known and used since ancient times (Poór et al., 2005; Pessot et al., 2021). The importance of treatments based on these factors has increased in recent years, as the importance of maintaining and regaining health has been enhanced in ageing societies. There are many opportunities for this in the areas of prevention and recreation (Magyar, 2016), curative care and rehabilitation for chronic conditions (Mayer & Hojcska, 2018). The application of these options varies across cultures, and natural conditions are not uniformly distributed around the world. Research shows that the use of natural-healing factors for health is widespread on all continents but is also prominent in Europe in terms of quantity and quality (Munteanu et al., 2013; Munteanu et al., 2019; Szabó et al., 2023).

Due to Hungary's geographic location and favourable geological conditions, there are numerous natural-healing factors in different regions of the country, which provide the basis for spa treatments as part of the healthcare system. Medicinal water treatments in medicinal water facilities are primarily used for the treatment of musculoskeletal disorders, but can also be applied in the treatment of other diseases (e.g. neurological, cardiovascular, respiratory). Spa medicine, which used to be empirically based, has become increasingly recognised thanks to evidence-based medicine (EBM) research in recent decades (Cheleschi et al., 2020). However, there is still very little international research on the health geography of the natural-healing factors that underlie the medicinal water treatments (Hojcska et al., 2021; Hojcska & Szabó, 2021). Health geography is concerned with the evolution of the health status of the population and the healthcare system (quality and accessibility of care), which has become a separate branch of social geography (Pál, 2013; Brace et al., 2023). In this field, Hungarian researchers have mainly focused their surveys on the health status and quality of life of the Hungarian population and their territorial differences, as well as on the analysis of the characteristics of the healthcare system (Pál, 2017; Uzzoli, 2020; Komáromy et al., 2022) and its utilisation (Vitrai et al., 2010).

The regional differences in the access to myocardial infarction care (Tóth et al., 2018; Uzzoli & Beke, 2018; Uzzoli et al., 2019) and the availability of stroke care centres (Uzzoli et al., 2017; Szikora et al., 2024) in Hungary have been highlighted in the context of leading causes of death. They also examined the availability of cataract surgery (Uzzoli et al., 2011; Pónusz et al., 2022) and the territorial characteristics of ambulance care (Kemkers, 2010; Bugya et al., 2015).

Social geography, tourism geography and settlement development play a significant role in tourism development in Hungary. In the diverse world of tourism geography, the multi-factorial system of medical tourism has a complex impact on social and economic processes.

There is a consensus among geographers that social geography is the dominant segment of geographical science, but the definition of social geog-

raphy is debated by practitioners in the field both internationally and domestically (Gregory et al., 1994; Pirisi & Trócsányi, 2019; Arvai et al., 2020). Similar to the international situation, differences can be observed in the interpretation of social geography by Hungarian researchers. The concept, research areas and structure of social geography were also defined by Tóth (2002), according to which social geography approaches space from the perspective of society and its activities. In his 1998 study, József Nemes Nagy examines social and economic phenomena from the perspective of regional science through the interpretation of space (Nemes Nagy, 1998).

Social geography studies the spatial relationships of social phenomena and processes, which is organically linked to tourism geography, tourism and settlement development, with the increasing appreciation of health and the increasing life expectancy (Fodor – Papp, 2013) and the problems of an aging population.

Tourism, as an important segment of the world economy, plays an important role in both the European and domestic dimensions of development policy (Radics, 2008; Pénzes et al., 2014; Sharpley – Telfer, 2015). Many countries therefore evaluate tourism and the related settlement development as a breakthrough opportunity (Aubert, 2001).

In Hungary, at the beginning of the 2000s, the government recognised the potential of domestic health tourism and began to develop and implement development plans. After joining the European Union, the opportunities for the development of health and medical tourism in settlements became progressively wider (Budai – Székács, 2001; Hangodi – Bán, 2015; Martyin-Csamangó, 2020). The Széchenyi Plans (Budai, 2001) played a decisive role in the implementation of the tourism-oriented developments of settlements – 2000–03: Széchenyi Plan: spa and accommodation development, ten-year development program of health tourism (Budai, 2002); 2004–06: *National Development Plan I; 2007–08: National Development Plan II. (New Hungary Development Plan 2007*); 2007–13: *New Széchényi Plan*: Healing Hungary Health Industry Program; 2020: *Széchenyi* 2020: a summary of the development goals of ten operational programmes; 2021–27: *Széchenyi Plan Plus* – (ÚMFT, 2007; Széchenyi, 2020), while health-related developments were promoted by the Semmelweis Plan (Semmelweis Plan, 2011). The framework for the next phase of domestic tourism development was defined by the Hungarian Tourism Agency in 2017, for the first time for a ten-year period within the framework of the National Tourism Development Strategy 2030 (NTS, 2030). However, in recent years, the COVID-19 pandemic has had a significant negative impact on tourism worldwide (Navarrete, 2021) and in Hungary, as a result of which a revision of the strategy has already become necessary. Taking all this into account, the development strategy already includes a plan to reduce the constant competitive situation and growing territorial inequalities that have come to the fore during the regime change, of which health and medical tourism can be an important part during the development of spa towns (Bujdosó – Radics, 2010; Dávid et al., 2010; Bujdosó et al., 2013).

Our study is concerned with the regional health geography analysis of natural-healing factors in Hungary, for which we consider it important to briefly present the natural-healing factors used in the country's spa medicine.

The natural-healing factors recorded in Hungary are elements of the natural environment, which are natural treasures of great importance, and their conservation is therefore important. To this end, natural-healing factors are protected by law (Borszéki, 2019). In Hungary, mineral waters, medicinal waters and other natural-healing factors such as medicinal mud, medicinal caves and medicinal gases are registered as natural-healing factors. Thermal climates can also be included, but their data are not part of the health databases and are therefore not the subject of our analysis.

In Hungary, natural mineral water is water that comes naturally or from groundwater aquifers subject to protective measures (Table 1).

The mineral waters of Hungary are classified into several groups according to their chemical properties (Schulhof, 1957), with minor differences in classification between the various literatures. The main groups of mineral waters are: earthy-calcareous waters (calcium-magnesium-bicarbonate); alkaline waters; sulphidic waters; sulphate waters; ferruginous waters; carbonic waters; radon waters and radioactive waters (Csermely, 2001; Tefner et al., 2011).

Here it is also important to highlight the concept of thermal water, which is not included in the above-mentioned regulation, but which is essential for the spa medicine used in Hungarian spa towns. According to the definition of the geothermal gradient, the temperature of the water entering the rocks in the interior of the Earth also increases gradually with depth. This temperature rise in the Carpathian Basin increases by 1 °C every 20 meters, compared to an increase of 1 °C every 30–33 metres in other areas of Europe, so there is no international consensus on the definition of thermal-water temperature (Bender & Géher, 2007). In Hungary, thermal water

Table 1. Biologically active substances in natural mineral water

For external use	
Lithium ion	at least 5 mg/l
Sulfide ion or titratable sulfur	at least 1 mg/l
Bromide ion	at least 5 mg/l
Iodide ion	at least 1 mg/l
Metasilicic acid	at least 50 mg/l
Radon activity	at least 37 Bq/l
Free carbon dioxide	at least 1000 mg/l
For internal use	
Sodium ion	less than 200 mg/l
Magnesium ion	at least 20 mg/l
Calcium ion	at least 60 mg/l
Fluoride ion	0.8 mg/l
Free carbon dioxide	at least 1000 mg/l

Source: Own author's draft basing on data from Bártfai, 1999

(hévíz) is defined as mineral water with a temperature above 30 °C at the point of surface outburst, i.e. water with a temperature above 30 °C at the point of outburst is considered to be hot water (hévíz), or thermal water (Gáspár, 2009; Nagy, 2016).

As with thermal waters, the situation in Hungary is unique as regards mineral waters. Natural mineral water extracted in Hungary is used in medicinal procedures, the legal framework for which is also unique in our country. The use of the term "medicinal water" and the use of medicinal water in spa treatment (subsidised by the social security system) is only possible with the permission of the Government Office of Budapest. The regulation also applies to other natural-healing factors. Accordingly, natural mineral water with proven therapeutic properties may be called and used as medicinal water. A medicinal effect is considered to be proven if its presumed effect is confirmed by duly documented and evaluated results of medical observations carried out according to scientifically recognised methods. The efficacy of Hungarian medicinal waters has been confirmed by numerous international and national publications (Zsirai, 1962; Bender et al., 2014; Bender, 2021).

Other natural-healing factors include medicinal mud, medicinal gases and medicinal caves, which are subject to the same legal provisions as medicinal waters as regards their designation and medicinal use.

Natural mud is defined as mineral and vegetable matter (marshland, peat, etc.) naturally produced in the aquatic environment, which, in its occurrence or in its ground state, is typically mud-like and has a significant water-holding capacity. A natural sludge is a medicinal sludge if its composition is known, it does not contain any substance harmful to human health, the conditions under which it is extracted comply with public health requirements and it has a scientifically recognised medicinal effect in the form in which it is used without any change to its original composition. The extraction, packaging and further use of medicinal sludges are also subject to strict legal requirements (Gyarmati, 2014; Király et al., 2020).

In Hungary, there are currently six types of medicinal mud registered by the NNK for use in medicine (Table 2).

In Hungary, the use of a substance (e.g., a gas) with a presumed medicinal effect, whether naturally issuing from the surface or artificially extracted from the ground, is allowed for medicinal purposes if its composition is known and nearly constant. Furthermore, if it does not contain any substance harmful to health in the form in which it is used and if it has a scientifically recognised medicinal effect under the intended conditions of use at the place of occurrence without any change in its original composition. The source of the medicinal gas is a cavity in the ground, at the bottom of which carbon dioxide gas erupts. An amphitheatre-style treatment area will be created around the naturally occurring gas, where patients will be treated at different levels. The use of thermal gases is present in Hungarian medicine as a spa, mainly for the treatment of circulatory diseases (László, 2000; Gomez, 2011; Szalainé & Dózsa, 2011; Nagy & Donáth, 2014). There are currently two thermal gas spas registered by the NNK

Table 2. Registered medicinal mud in Hungary

Settlement	County	Designation
Makó	Csongrád-Csanád	Marosi medicinal mud
Tiszasüly	Jász-Nagykun-Szolnok	Marosi medicinal mud
Hajdúszoboszló	Hajdú-Bihar	Mud of City Medicinal Bath
Alsópáhok	Zala	"Georgikon" natural peat medicinal mud
Alsópáhok	Zala	Szent András natural medicinal mud
Neydharting	Austria (Federal State of Upper Austria)	Neydharting medicinal mud

Source: Own author's draft basing on data from National Public Health Center, 2024

in Hungary – both in Heves county. One of them is the Erzsébet Park Hotel Mofetta in Parádfürdő, and the other is the Mofetta Carbon Dioxide Medical Gas Bath in Mátraderecske.

In the mofetta treatment (carbon dioxide dry bath) at the Erzsébet Park Hotel in Parádfürdő, the pool is filled with carbon dioxide, where the clothed, seated patient receives the treatment in carbon dioxide medicinal gas up to chest height. The mofetta gas in Parádfürdő has a high carbon dioxide and (almost 90% by volume) radon content (125 kbq/m3) and also contains oxygen, nitrogen and methane. The gas, which is related to volcanic activity, erupts from a depth of about 1000 metres from the ground (Gubacsi, 2017). In terms of its physiological effects, the treatment has a vasodilating, general well-being-improving and immune-system-stimulating effect and is therefore best used in the therapy of vascular, musculoskeletal and rheumatological diseases, as well as diabetes. During the procedure, carbon dioxide enters the body through the skin, while the patient experiences the characteristic sensation of warmth, flushing and sweating. The treatment is carried out under the supervision of healthcare professionals, and the duration of the treatment is 25 minutes per day, for at least two weeks, which is worth repeating as a course of treatment (Mofetta, 2025).

In the Mofetta carbon dioxide medicinal gas bath in Mátraderecske, the gas evaporation resulting from volcanic after-effects can be used as a physio-balneotherapy treatment. Its use dates back several millennia. In the 1st century, Celsus and Pliny treated their patients in amphitheatre-like pools (mofettas), and, in the 16th century, Paracelsus used the medicinal gas for burns, ulcers and women's diseases. The gas that comes to the surface in the Mátraderecske area comes from large, highly fragmented Triassic karst water-storage layers. The gas seeps near the surface through the deep Eocene volcanic andesite, where it erupts from a depth of 1000 m under the cover of young gas-trapping sediments at an average rate of 400 l/h (Nagy, 2014). The vasodilating effect of carbon dioxide gas was described by Lister in 1858, and the treatments were further developed in the last century, which is attributed to R. Cobet, H. Hediger and G. Parade between 1929 and 1932. The Mofetta in Mátraderecskei, located on the northern side of the Eastern Mátra, received medicinal gas in 1999, and the medical center was certified as a medicinal gas spa institution in 2006. The composition of the gas: Oxygen – 1.61 vol %, Nitrogen – 7.13 vol %, Methane – 5.11 vol %, Carbon dioxide – 86.16 vol %, radon content is relatively high, radioactivity / 222 Rn / 125 kBq/m3 (Mofetta Mátraderecske, 2025).

The effect of the Mátraderecské medicinal gas was studied between 1995 and 1999 (N=800), which study showed that, in patients with vasoconstriction, 15x20-minute mofetta treatment improved walking distance and reduced lower limb pain among the treated patients (László, 2000).

Both institutions are significant in terms of the domestic medical tourism offer (Csapó & Marton, 2017; Zsarnóczky, 2017).

The beneficial effects of caves on the body can already be read in the writings of Hippocrates (Horvath, 1986; Nagy, 2014). Cave therapy belongs to the category of climatotherapy, as its special climate creates the healing effect, especially in the case of respiratory and musculosceletal diseases. A medicinal cave is a natural cave or other underground area (mine, shaft) that is properly designed and equipped and has proven therapeutic properties, using its special atmospheric conditions to treat certain diseases. Of the more than 3,700 caves registered in Hungary (Nyerges & Takácsné, 2004; Béki et al., 2016), there are five caves that can be considered as natural-healing factors (Table 3).

The treatment that can be carried out in the medicinal caves is speleotherapy, a special form of climatotherapy (Juhász et al., 2019). Caves are divided

Table 3. Medicinal caves registered in Hungary

Settlement	County	Name of medicinal institution
Jósvafő	Borsod-Abaúj-Zemplén	Peace cave
Tapolca	Veszprém	City Hospital
II. district	Budapest	Szemlőhegy cave "Giant corridor"
Miskolc	Borsod-Abaúj-Zemplén	Miskolc-Lillafüred István Cave "Black Room"
Abaliget	Baranya	Abaliget Cave "Medicine Room"

Source: Own author's draft basing on data from National Public Health Center, 2024

into two groups according to their temperature: cold and hot caves. In both cases, the caves have a specific microclimate and the physical and chemical stimuli they provide have a beneficial biological effect on the human body. A specific characteristic of caves is the extremely clean, allergen-free, calcareous air, free of irritants (soot, gases), which has an anti-allergic and anti-inflammatory effect. They are also characterised by a high ionic content, absence of fronts and constant temperature and air pressure. Furthermore, the high carbon dioxide content improves oxygenation (Kessler, 1982). Warm caves are mainly used for the treatment of musculoskeletal disorders, while cold caves are used for the treatment of respiratory diseases. There are cold caves in Hungary, of which the highest temperature is around 19 °C in Tapolca.

These natural treasures and the medicinal water treatment institution system they provide form an integral part of the health care of the Hungarian population, especially for patients with musculoskeletal disorders. Our goal is to facilitate the development of a modern, scientifically sound, practically functional decision-preparation system for managers in the decision-making process of regional developments based on natural-healing factors, by extensively applying the systems approach.

2. Research materials and methods

In order to achieve our research objective, i.e. to explore the regional disparities of natural-healing factors in Hungary, we used the data of the NNK 2023 for the counties of the examined factors (Table 4). To carry out our analysis, we aggregated the basic statistical data at regional level and used the resulting data for the territorial analyses. The data for the Pest region and the Budapest region are aggregated and analysed as Central Hungary region data in order to weight the area sizes. The data used for the territorial calculations are summarised in Table 5.

The regional territorial disparities of natural-healing factors in Hungary are investigated using territorial research methods. For the analysis of territorial polarisation, we use measures of the extent ratio, the range of dispersion, the relative extent and the dual index (Éltető–Frigyes index), and the differences in territorial distributions are determined using the Gini index, the Hirschman–Herfindahl index and the Hoover index (Table 6).

We evaluate our results according to the ranges of interpretation defined in the relevant literature. When applying the Gini index, researchers already accept a value around 0.4 as a relatively significant inequality. A value above 0.6 for the Hirschman–Herfindahl index already indicates a high degree of concentration. The Hoover index shows the territorial concentration of the factor under study in percentage terms.

Limitation

The limitation of our research is, on the one hand, that the natural-healing factors in Hungary have already been examined in detail in our previous research at the NUTS3 level. On the other hand, regional development, especially with regard to EU subsidies, is not implemented at the NUTS3 level, but at the NUTS2 level, which is why we chose this as the territorial level of our research.

3. Research results

In line with our research objective, the results of our regional territorial analysis of natural-healing factors in Hungary are presented in three subsections. The first sub-chapter presents the aggregated results

Table 4. Natural healing factors in the counties of Hungary

NUTS3 area (county)	Mineral waters	Medicinal waters	Other natural healing factors			Total other natural healing factors
			Medicinal muds	Medicinal caves	Medicinal gases	
Budapest	16	20	0	1	0	1
Baranya	9	8	0	1	0	1
Bács-Kiskun	29	18	0	0	0	0
Békés	5	14	0	0	0	0
Borsod-Abaúj-Zemplén	16	9	0	2	0	2
Csongrád-Csanád	6	16	1	0	0	1
Fejér	17	5	0	0	0	0
Győr-Moson-Sopron	12	12	0	0	0	0
Hajdú-Bihar	17	29	1	0	0	1
Heves	8	15	0	0	2	2
Jász-Nagykun-Szolnok	7	28	1	0	0	1
Komárom-Esztergom	12	3	0	0	0	0
Nógrád	1	2	0	0	0	0
Pest	38	12	0	0	0	0
Somogy	16	13	0	0	0	0
Szabolcs-Szatmár-Bereg	11	19	0	0	0	0
Tolna	6	10	0	0	0	0
Vas	10	19	0	0	0	0
Veszprém	22	2	0	1	0	1
Zala	16	16	2	0	0	2
Total (pcs)	274	270	5	5	2	12

Source: Own author's draft basing on data from National Public Health Center, 2024

Table 5. Natural healing factors in the regions of Hungary (NUTS 2)

Region	Mineral waters (pcs)	Medicinal waters (pcs)	Total other natural healing factors (pcs)
Northern Great Plain	35	76	2
Southern Great Plain	40	48	1
Central Hungary	54	32	1
Northern Hungary	25	26	4
Western Transdanubia	38	47	2
Central Transdanubia	51	10	1
Southern Transdanubia	31	31	1
Total (pcs)	**274**	**270**	**12**

Source: Own author's draft basing on data from National Public Health Center, 2024

Table 6. Territorial research methods used

TERRITORIAL INDEX		FORMULA
Measurements of territorial polarization	**Extent ratio (K)**	$K = X_{max} / X_{min}$
	Range of dispersion (R)	$R = X_{max} - X_{min}$
	Relative extent (Q)	$Q = \frac{X_{max} - X_{min}}{\overline{X}}$
	Dual index (D) (Éltető–Frigyes index)	$D = \frac{\overline{X_m}}{\overline{X_a}}$
Measurements of the deviation of territorial distributions	**Gini index (G)**	$G = \frac{\Sigma_{i=1}^{n}\Sigma_{i=1}^{n}\lvert y_i - y_j\rvert}{2 * \bar{y} * n^2}$
	Hirschman – Herfindahl index (HI)	$HI = \Sigma_{i=1}^{n} (x_i/\Sigma x_i)^2$
	Hoover index (h) (%) with population	$h = \frac{\Sigma_{i=1}^{n}\lvert x_i - f_i\rvert}{2}$

Source: Own author's draft basing on Antonescu, 2020; Bhandari, & Hanna, 2022; Duque et al., 2023; Gregics, 2023

of the mineral waters, the second the medicinal waters and the third the other natural-healing factors.

Among the regions of Hungary, the numbers of natural-healing factors recorded by the NNK are not uniform, as illustrated in Fig. 2.

Looking at the total number of natural-healing factors of the regions (274), the leading region in terms of mineral waters is Central Hungary (54), followed by Central Transdanubia (51) and then Southern Great Plain (40). The other four regions also have a significant number of mineral waters, ranging from 38 to 25. Of the 270 thermal springs, the Northern Great Plain region stands out with 76 thermal springs. It is followed by the Southern Great Plain region (48) and the Western Transdanubia region (47). The other regions also have a high number of these natural-healing factors, as even the region with the fewest thermal springs (Central Transdanubia) has 10 certified thermal springs. Looking at the aggregated regional data for other natural-healing factors (medicinal mud, medicinal gas, medicinal cave), it was found that the region of Northern Hungary has the highest number of these natural factors (4). This is followed in order by the Northern Great Plain and West Transdanubia regions, each with two other natural-healing factors. The remaining four regions were found to have at least one other natural-healing factor in each region, in addition to mineral and medicinal waters.

These data were further analysed using the methods of the regional survey, which resulted in the following calculations.

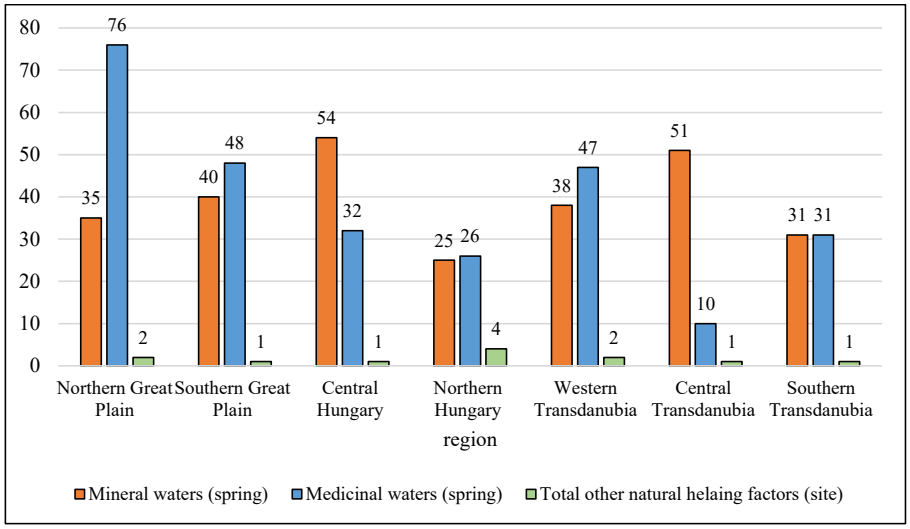

Fig. 2. Number of natural healing factors in the regions of Hungary
Source: Calculated and edited by authors, based on National Public Health Center, 2024

3.1. Results of regional studies on mineral waters

Examining the territorial polarisation based on regional mineral water data, we found that the Hungarian mineral waters have an extent ratio of K=2.2; a range of dispersion of R=29.0; a relative extent of Q=0.7, and a dual index of D=1.5. Further examining the variation in the territorial distribution of the data, we found that the Gini index for mineral waters: G=0.07; Hirschman–Herfindahl index: HI=0.151; and Hoover index: h=16%. Overall, these results show that mineral waters in Hungary exhibit relatively significant territorial inequality and weak medium concentration at regional level (Fig. 3).

Based on the regional territorial analyses, the highest concentrations of mineral waters can be found in Central Hungary (54) and Western Transdanubia (51), followed by Southern Great Plain (40) and Western Transdanubia (38). There are 35 mineral waters in the Northern Great Plain region and 31 in the Southern Transdanubia region, while the Northern Hungary region (25) has the lowest concentration of this natural-healing factor.

3.2. Results of regional studies on medicinal waters

Examining the territorial polarisation based on regional medicinal water data, we found that the extent ratio of medicinal waters in Hungary is K=7.6; the range of dispersion is R=66.0; the relative extent is Q=1.7, while the dual index is D=2.3. Further examining the territorial distribution of the data, the Gini index for medicinal waters is G=0.14; the Hirschman–Herfindahl index is HI=0.179; and the Hoover index is h=28%. Based on the calculated territorial indices, the overall territorial differences of the Hungarian medicinal waters are characterised by a medium territorial inequality and a relatively high concentration (Fig. 4).

Based on the regional analysis of the medicinal waters, it is stated that the Northern Great Plain region (76) has the highest concentration of these groundwaters. In comparison, the concentration is lower in the Central Hungary region (58), followed by the Southern Great Plain (48) and the Western Transdanubia region (47). The number and concentration of qualified medicinal waters is signif-

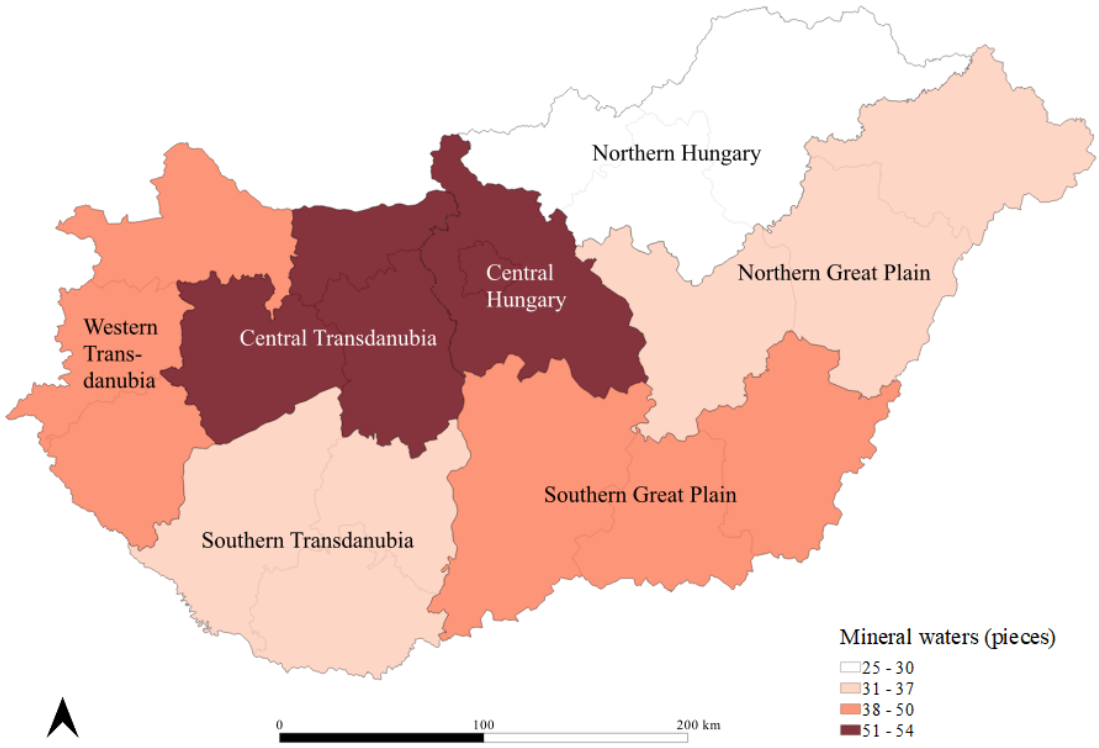

Fig. 3. Regional differences in mineral waters
Source: Own elaboration

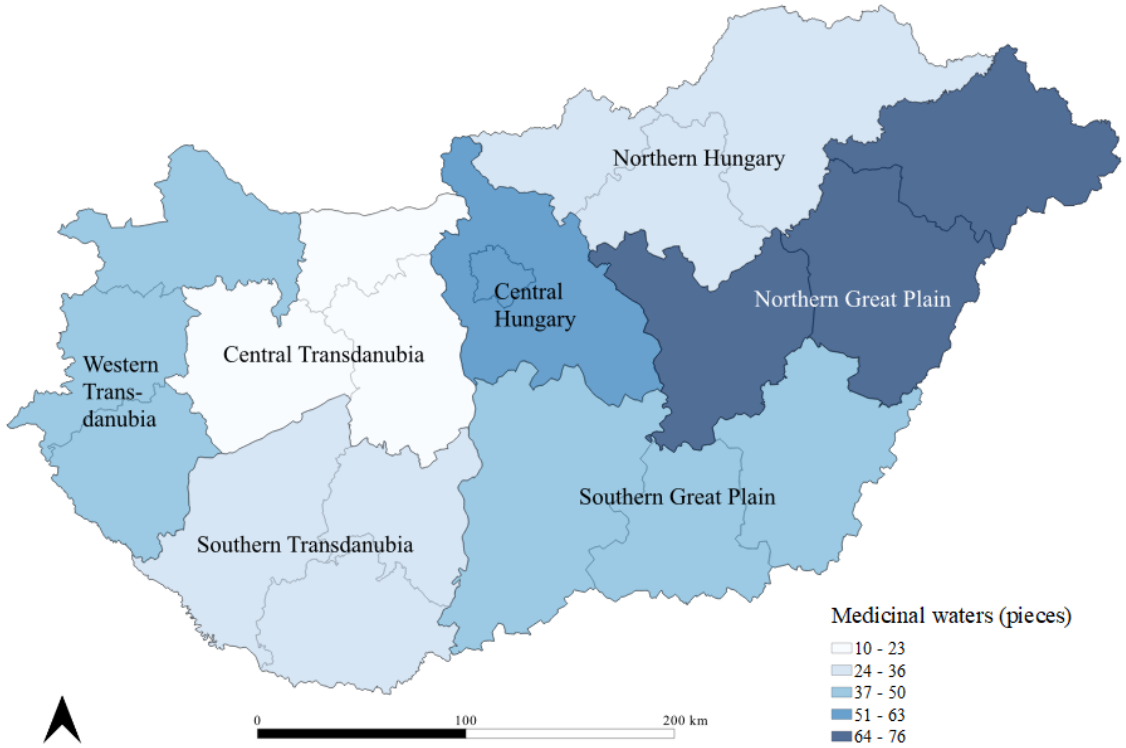

Fig. 4. Regional differences in medicinal waters
Source: Own elaboration

icantly lower in the Southern Transdanubia (31) and Northern Hungary (26) regions, and the Central Transdanubia region (10) has the lowest concentration in the country.

3.3. Results of aggregated regional studies of other natural-healing factors

Examining the territorial polarization based on regional other natural-healing factor data, we found that the extent ratio of other natural-healing factors in Hungary is K=4.0; the range of dispersion is R=3.0; the relative extent is Q=1.7, while the dual index is D=2.7. Further examining the variation in the territorial distribution of the data, we found that the Gini index for other natural-healing factors: G=0.14; Hirschman–Herfindahl index: HI=0.194; and Hoover index: h=30%. From the results obtained, it is determined that the regions of Hungary are characterised by a medium territorial disparity and a relatively high concentration of other natural-healing factors (Fig. 5).

Based on the total number of other natural-healing factors, the regional concentration of these medicinal substances is clearly highest in the Northern Hungary region, followed by the Northern Great Plain and West Transdanubia regions.

4. Discussion and conclusions

The quantity and quality of Hungary's natural-healing factors are outstanding in European terms. These natural treasures are of considerable tourist value. This is especially true for thermal-medicinal bath tourism, which is the basis of tourism in Hungary and an integral part of healthcare and the improvement of the health of the population, mainly with regard to musculoskeletal health. In addition to evidence-based effectiveness studies of natural-healing factors, regional territorial studies are becoming increasingly important, and our research in this field can be considered as a niche area. In order to achieve our research objective, we determined the regional disparities of natural-healing factors in Hungary (Table 7).

These results can help in planning sustainable tourism development and urban development. In addition, our data can be used for territorial comparisons of natural-healing factors in other countries and for cross-border regional cooperation.

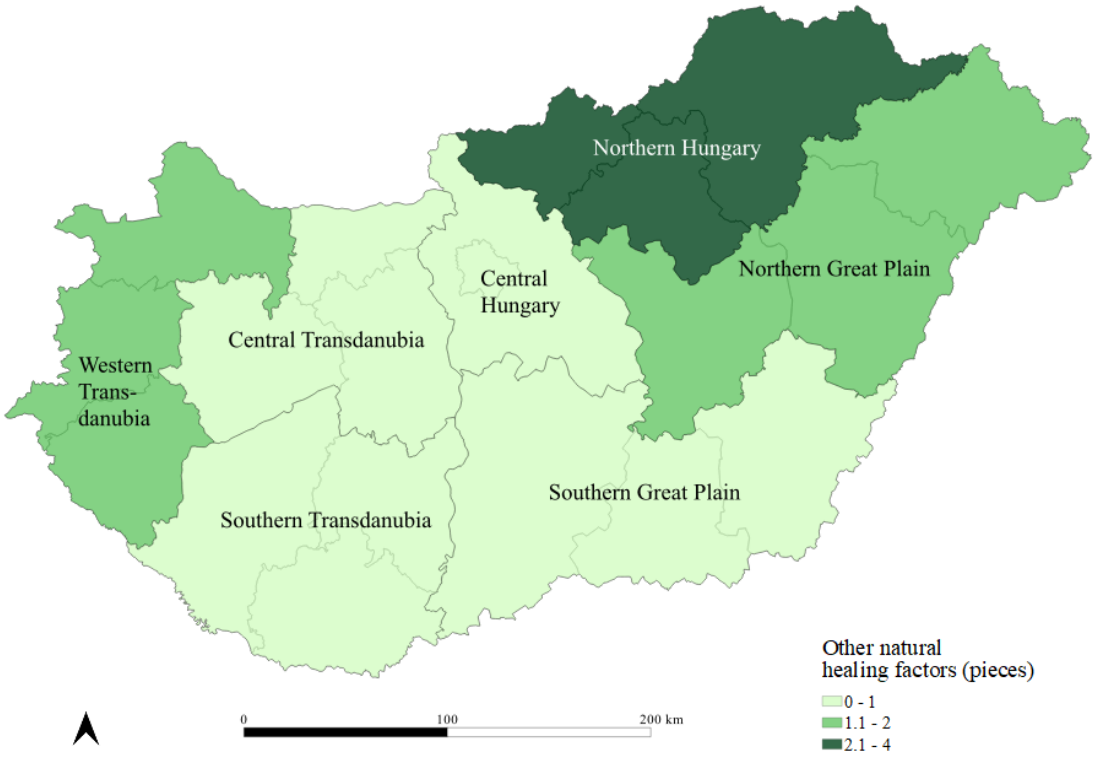

Fig. 5. Regional differences in other natural healing factors
Source: Own elaboration

The Carpathian Basin, including Hungary, is home to an outstanding groundwater resource in terms of quantity and quality due to its hydrogeological characteristics. Favourable geothermal conditions ensure the uniqueness of the water temperature, which provides the base for thermal-medicinal bath tourism. In addition to geological conditions, the distribution of the available natural-healing factors also shows territorial disparities and can therefore be analysed at regional level. This is based on the Nomenclature of Territorial Units for Statistics (NUTS). The regions have different characteristics, and regional mapping and analysis of the natural-healing factors that underpin the thermal-medicinal bath tourism sector as a key economic sector is essential for their proper development. For this purpose, we have carried out a regional analysis of natural-healing factors in Hungary according to their application in health tourism, including spa therapy (mineral water, medicinal water, other natural-healing factors) and presented our results.

In our research, we examined the territorial disparities of natural-healing factors in Hungary at the internationally accepted regional level. For the analyses, we applied appropriate territorial research methods based on the literature to determine territorial polarization and concentration. Based on our results, we have determined the territorial disparities of the natural-healing factors registered in Hungary (274 mineral waters, 270 medicinal waters and 12 other natural-healing factors). We found that mineral waters have a relatively high territorial inequality and a weak medium concentration, while medicinal waters and all other natural-healing factors have a medium territorial inequality and a relatively high concentration in Hungary. Based on our results, we conclude that, including for medicinal waters, but especially for other natural-healing factors, the levelling of territorial disparities may be difficult and costly, but necessary. Furthermore, we found that the applied territorial research methods are well-suited for exploring regional territorial disparities in medical tourism in Hungary and, on this basis, internationally. We have developed a decision-making system for regional developments based on natural medicinal factors, with indicators and maps. The elements of the system approach are the medicinal healing factors inequality index, variability index,

Table 7. Results of regional territorial studies

Natural healing factors	Territorial indicators						General indicators			
	Extent ratio (K)	**Range of dispersion** (R)	**Relative extent** (Q)	**Dual index** (D) (Életű – Frigyes index)	**Gini index** (G)	**Hirschman – Herfindahl index** (HI)	**Hoover index** (h) (%) with population	Minimum (pcs)	Maximum (pcs)	Average (pcs)	Total
Mineral waters	2.2	29.0	0.7	1.5	0.07	0.151	16%	25	54	39.01	274
Medicinal waters	7.6	66.0	1.7	2.3	0.14	0.179	28%	10	76	38.6	270
Total other natural healing factors	4.0	3.0	1.7	2.7	0.14	0.194	30%	1	4	1.7	12

Source: Calculated and edited by authors.

concentration index and territorial distribution index, as well as maps facilitating regional comparison, which are planning, decision-making and support tools at all hierarchical managerial levels.

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