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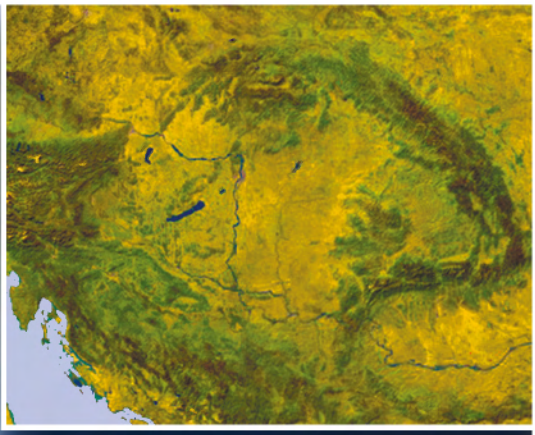

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Towards a multiscalar perspective on the prospects of 'the actually existing smart village' – a view from Hungary

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Abstract

This paper aims at expanding the scope of the dominantly pragmatic, local scale-oriented smart village scholarship towards a perspective that recognizes that smart village development is a multiscalar political process. To show the necessity of this move, the shaping of smart village policies and practices in Hungary is examined through a qualitative lens. As the authors argue, path-dependent structural obstacles and interscalar relations undermine the prospects of smart village building in the sense of bottom-up integrated rural development, and there is a risk of a bias towards technological innovation. This exploratory article, using Hungary as a case study, argues that smart village scholarship should draw on the results of critical smart city scholarship to acquire in-depth understanding of current debates regarding potential smart village developments.

Keywords: smart village, smart rural development, rural development, digitalisation, Hungary, multiscalar perspective

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Introduction

Expanding on the focus on 'the smart city' in policymaking and scholarly research concerned with the use of digital technologies for the improvement of urban management (Kitchin, R. 2014, 2015; Karvonen, A. *et al.* 2018; Joss, S. *et al.* 2019), recently one could witness a growing interest in the smart development of rural areas. The European Union has incorporated 'smartness' into its rural development policy, and the 'smart village' concept has been proposed as a way of addressing the challenges faced by rural areas such as depopulation and funding cuts, boosting local economies and improving quality of life through a combination of technological and social innovation (ENRD, 2018; Zavratknik, V. *et al.* 2018; Komorowski, L. and Stanny, M. 2020). Parallel to this, more and more scholars (Hosseini, S. *et al*. 2018; Visvizi, A. and Lytras, M.D. 2018; Spicer, Z. *et al.* 2019; Cowie, P. *et al.* 2020) have called for extending (the study of) smart development to rural areas. This paper is motivated by the observation that although this emerging scholarship has provided useful insights on smart village policies and practices, it has been characterized by a rather narrow focus on local conditions and has unduly maintained a pragmatic solution-oriented stance. While agreeing that "(t)he rural should no longer be the tailpiece of urban-centred research on smart development" (Cowie, P. *et al.* 2020, 175), this paper argues that smart village research can usefully draw on the perspective of critical smart city scholarship (Verrest, H. and Pfeffer, K. 2019) to acknowledge that the 'actually existing smart village' – akin to the 'actually existing smart city' (Shelton, T. *et al.* 2015) – is

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the product of multiscalar political processes. To demonstrate the usefulness of a broader political-economic view, the paper presents the findings of a qualitative exploratory study of the shaping of smart rural development policies in Hungary, where smart rural development has recently begun to receive more explicit national policy attention through the launch of the Digital Village Programme (DVP). Based on the (preliminary) evaluation of this emerging policy agenda, the paper argues that although the policy discourse in Hungary has reiterated the emphasis on the bottom-up character of smart village development and the need to combine technological innovation with social innovation, a lack of policy coordination and the weak(ening) position of the local scale makes the realisation of smart villages questionable.

The main aim of this article is to analyse how digitalisation policies and "smartening" efforts may take effect in the Hungarian context and what incentives affect the use of info-communication technologies (ICTs) in rural areas. We argue, contrary to the pragmatic solution-oriented focus and coupled with an emphasis on the local context, that smart village development needs to be examined as a broader multiscalar policy process, as this provides a more complete picture of barriers and opportunities.

In other words, a key question is to what extent interscalar power relations across different policy fields facilitate or impede the development of the bottom-up approach that is considered to be fundamental to the smart village.

The emergence of 'the smart village' as a policy concept

The notion of 'smart' first appeared in the discourse on cities as part of an urban policy approach that emerged in the 1990s and which has since emphasized the importance of ICTs and business-led initiatives for solving urban problems (Hosseini, S. *et al.* 2018; Spicer, Z. *et al.* 2019). According to some, the recent upsurge of interest in the smart city has been driven by the ICT corporate sector promoting a technocratic urban policy approach with the aim of selling technological solutions (Söderström, O. *et al.* 2014; Wiig, A. 2015). In addition, critical approaches to the smart city highlight that the spread of the smart city concept can also be interpreted as part of a neoliberal market-oriented transformation process in the urban space, with the main interest being to increase the value of urban space as a commodity together with the concentration of R&D capital (Greenfield, A. 2013; Vanolo, A. 2014; Grossi, G. and Pianezzi, D. 2017). As competition between cities increases, the concept of smart city needs to be re-conceptualized as a discourse network, permeating and binding together various geographical scales (Joss, S. *et al.* 2019). In the European context, another source of the popularity of smartness has been research in the field of the economics of innovation on (regional) smart specialisation conducted for the European Commission (Torre, A. *et al.* 2020). In the post-2008 crisis period, the concepts of smart, sustainable and inclusive growth became the cornerstones of the 'Europe 2020' growth strategy launched in 2010, with the aim being to address the structural weaknesses of the EU economy (Naldi, L. *et al.* 2015; Haarstad, H. 2017). The growth strategy also marked the start of a new generation of regional innovation policy promoting 'smart specialisation', an approach emphasizing the role of endogenous resources (Rosa Pires da, A. *et al.* 2014) and a broader-than-technological understanding of innovation (European Commission, 2010 a, b).

Within the EU, the introduction of smartness into the field of rural development can be primarily linked to the above EU regional policy shift (Philip, L. and Williams, F. 2019) and to the application of the smart concept – in the sense of smart specialisation – on a territorial scale that goes beyond the urban space (European Parliament, ECORYS, 2019). Building on this framing of smart rural development in terms of sustainable economic development, the smart village concept has

appeared more recently to emphasize the potential role of ICTs in addressing the "circle of decline" that is maintained in rural areas by two mutually reinforcing trends, namely, a shortage of jobs and sustainable business activity and inadequate and declining services (see ENRD, 2018). These issues and the importance of ICT for rural regions has already been identified by the Europe 2020 strategy (Naldi, L. *et al.* 2015), but it is only in the past five years that the notion of the smart village has entered the EU's policy vocabulary. Consequently, relatively few smart village concept-related projects have been implemented.

Definition of the smart village

The definition of the smart village[3] proposed by the EU Action for Smart Villages (see Zavratnik, V. *et al.* 2018) emphasizes the need of social innovation on the basis of existing strengths and regarding digital infrastructure as a catalyst of, rather than as a sufficient condition for, digital innovation (ENRD, 2018, 7). The definition extends earlier conceptualizations of smart rural development in terms of smart specialisation. More recent policy initiatives – for example, the European Innovation Partnership for Agriculture (EIP-AGRI) and the European Network for Rural Development (ENRD) – and the *Bled Declaration for a Smarter Future of the Rural Areas in EU* (2018) have marked a new approach that accords digital technologies a more explicit and pivotal role.

It is important to point out that technological development in itself (e.g. installing smart benches, establishing public space wifi networks) should not be regarded as constituting a smart village. Smart villages are rural communities which rely on participatory planning and seek to develop their services based on their local characteristics by using ICT (thereby reinterpreting the rural way of life).

Smart villages can be understood as innovative and resilient communities that use the mobilization of internal resources (local values and community) and the channelling of external resources (through the effective mobilization of a mix of tender resources) for institutional capacity building and service development. As part of this approach, ICT plays a central, but not exclusive, role, especially in such areas as resource sharing (e.g. shared cloud-based platforms between municipalities), e-commerce and public services (e.g. e-government). As global challenges also affect rural areas, environmental protection, green energy production, and the reduction of pollutant emissions in agricultural production are factors of consideration. Thus, locally based ecotourism (which can be well supported by application developments and using GIS tools in order to gather more data about landscape values, see Lontai-Szilágyi, Zs. *et al.* 2019) and shopping communities, overall quality living conditions for teleworkers in the post-COVID period serve as a potential breakthrough for rural areas. The essence of the smart village initiative is to connect community resources with information technology achievements, which are embedded in community innovation and development programs (*Figure 1*).

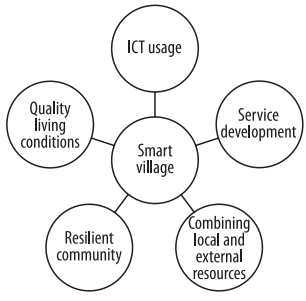

Fig.1. Main elements of the Smart Village concept. *Source:* Compiled by the authors.

[3] According to the 'EU action for Smart Villages', smart villages are "rural areas and communities which build on their existing strengths and assets as well as new opportunities to develop added value and where traditional and new networks are enhanced by means of digital communications technologies, innovations and the better use of knowledge for the benefit of inhabitants." (ENRD, 2018, 7)

Smart village projects in the EU, with special attention to V4 countries

To place our Hungarian case study into context, we conducted a collection of smart village initiatives among the Visegrád countries (V4: Czechia, Hungary, Poland and Slovakia). The sites and main objectives of the projects have been derived from the databases of EU-based networks and from the Final Report of the Pilot Project: Smart eco-social villages (European Parliament, ECORYS, 2019). It can be noted that the Visegrád region is underrepresented in the list of smart village projects in the analysed EU-wide databases: only a few initiatives can be highlighted in terms of community, infrastructure or even in organizational matters in the last few years (*Table 1*).

The listed V4-based smart village projects are also represented on a map (*Figure 2*). Specific smart village projects cover a large spectrum from "soft" strategy development (Smart Rural 21 Project, which is a network of settlements forming a smart village strategy, the main profile is technical assistance) to ENRD-supported local brand development (in Lower Silesia near Karpacz), circular economy-based business development (Dzialdowo) or agriculture modernisation (Panovce) using digital technologies. Carbon-free villages like Nagypáli and Tomaszyn are examples of environmental and energy-focused smart village developments. The map also shows the NUTS 3-level administrative division of the four countries based on the urban-rural typology of EUROSTAT. There are several urban-rural typologies, and each of them builds on a mix of statistical data, using different methodological approaches. (Novotny, L. *et al*. 2015). EUROSTAT identifies three types of region based on the share of the rural population, using clusters, which consist of 1 km² sized grid cells with different population intervals. The three spatial categories are predominantly rural regions (where at least 50% of the population live in rural grid cells), intermediate regions (where between 50% and 80% of the population live in urban clusters) and predominantly urban regions (where more than 80% of the population live in urban clusters).

Regarding the general features of smart rural development in these countries, local leadership plays a very important role, as does also external knowledge transfer (which can initiate developments). As researchers have noted, access to digital tools is not necessarily the only obstacle to smart rural development within this area, as this concept implies not only technological modernisation but also organizational, institutional and societal innovation (Vaishar, A. and Šťastná, M. 2019; Torre, A. *et al*. 2020). This requires a thorough (qualitative) analysis of the situation in rural areas in terms of local potentials and priorities Šipilova, V. *et al.* 2017) and the development of RIS (Research and Innovation Strategy) on a smaller scale (Pelse, M. and Lescevica, M. 2016).

Table 1. Overview of smart village initiatives in the Visegrád region

Location of smart village initiatives	Country	Description
Nagypáli	Hungary	Solar energy systems, innovation eco-centre, hybrid power plant
Koppányvölgy		Aquaculture; soil borehole heat pumps along with solar panels; insect breeding, hydroponics.
Alsómocsolád		Complex smart village program: smart tourism development, local currency, digital market
Ceglédbercel		Wireless LAN systems, CCTV
Uppony		Smart village strategy framing
Panovce	Slovak Republic	Modernisation of dairy production via digital systems
Mukarov	Czech Republic	Smart village strategy framing

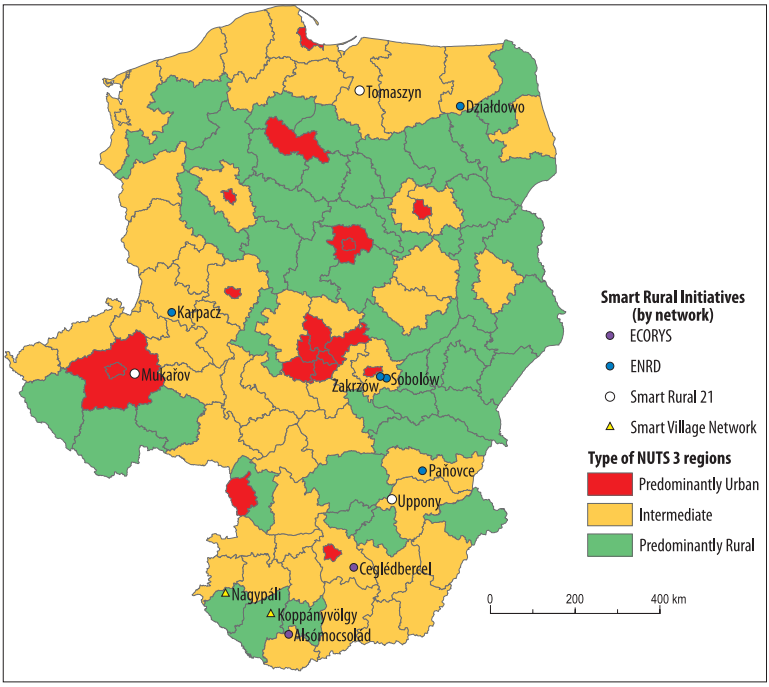

Fig. 2. Overview map of smart village initiatives in the Visegrád countries. *Source:* Eurostat, Smartrural21.eu, ENRD smart villages portal, smart-village-network.eu, European Parliament, ECORYS, 2019. Compiled by the authors.

Towards a multiscalar perspective on the smart village

Academic research on the implementation of smart villages is still in its infancy, but in the past years one could witness a proliferation of studies on this issue (Prause, G. and Boevsky, I. 2015; Zavratnik V. *et al*. 2018; Philip, L. and Williams, F. 2019; Vaishar, A. and Šťastná, M. 2019; Komorowski, L. and Stanny, M. 2020). A shared aim of emerging smart village scholarship so far has been to discuss, mostly against the backdrop of the EU's emerging smart development policy field, existing smart village initiatives and projects, and to assess their utility in revitalizing rural areas. Beyond emphasizing that good digital telecommunications infrastructure is essential (Philip, L. and Williams, F. 2019; Adamowicz, M. and Zwolińska-Ligaj, M. 2020), a key point of convergence is the focus on the facilitating and hindering factors of smart village implementation at the local scale. For example, Komorowski, L. and Stanny, M. (2020) and Guzal-Dec, D. (2018) mention the lack of skills and insufficient acceptance or awareness of new technologies as the main barriers to implementing the smart village idea; in a similar fashion, Vaishar, A. and Šťastná, M. (2019) refer to the lower education levels and conservatism of rural populations, and Zavratnik, V. *et al.* (2018) emphasize the importance of strategies and solutions based on local or regional knowledge. Although Adamowicz, M. and Zwolińska-Ligaj, M. (2020) acknowledge the relevance of the supportive policy of regional and central governments, they also refer to the active participation of business entities, local institutions, and citizens. This is echoed by Guzal-Dec, D. (2018)

who underlines the initiating, activating, and coordinating role of local authorities. Another related, yet often implicit commonality of smart village research is a pragmatic solutionist attitude, grounded in an (almost – see Philip, L. and Williams, F. 2019[4]) unquestioned belief in the positive effect of digital technologies on rural development. Hosseini, S. *et al.* (2018), for example, propose a blueprint for innovation processes that can stimulate digital innovation in smart towns. Káposzta, J. and Honvári, P. (2019) seem to be convinced that the smart village is a factor pointing towards the future. According to Visvizi, A. and Lytras, M.D. (2018, 2), "smart villages research has a very strong pragmatic orientation in that it seeks to diagnose a problem and, by reference to ICT, offer a way of bypassing it".

This paper acknowledges the need to investigate the local conditions for smart development, as well as that of societally relevant research on smart rural development. However, it argues that to develop a comprehensive understanding of (the prospects of) smart village building, it is necessary to apply a perspective that attends to the interscalar processes through which smart village development takes shape, as well as to the fact that the solutions that smart village building claims to provide are not neutral. For example, how digital tools and non-digital interventions are combined to address a perceived rural development problem is a matter of political decision that benefits some actors (e.g. ICT companies) and not others. Also, the application of smart technologies might address some problems but might create new patterns of exclusion if certain groups cannot access or make use of the technology.

The multiscalar perspective proposed by this paper builds on the assumption that just as smart city development does not unfold 'at' only one (the local) scale, smart village building has multiple scalar dimensions and is the result of power-laden institutionalized practices 'at' multiple (supranational, national, regional, and local) scales (cf. Varró, K. and Bunders, D.J. 2020), whereby actors variously positioned fill the smart village concept with different meanings. Drawing on insights from critical smart urbanism, smart village can, thus, also be interpreted as a political strategy involving actors 'at' different scales, promoting new arrangements for different policy areas and, by doing so, (re) shaping the institutional-territorial configuration of the state (cf. Smigiel, C. 2018). From this perspective, the focus is on what (implicit) claims are advanced by which actors, and how power relations among actors, actors' dependence on (external) resources, as well as coordination between relevant policy areas (or the lack of it) influence the actual course of smart village development. In other words, a key question is to what extent interscalar power relations across different policy fields facilitate or impede the development of the bottom-up approach that is regarded to be fundamental to the smart village. The remainder of the paper addresses this question regarding the case of Hungary, to assess the prospects of smart village development.

Methodology

The research had a qualitative exploratory nature and started off with the content analysis of (national and local) policy documents and websites of relevant institutions, focusing on how policy discourse and (envisaged) interventions frame the link between rural development and digitalisation. Furthermore, eleven in-depth semi-structured interviews were conducted in the period between September and December 2020[5] with key figures of the emerging smart rural development policy field. The research questions (see *Table 2*) were designed to investigate the research phenomenon in an open-minded way and to understand how key players of rural development such as mayors

[4] As Philip, L. and Williams. F. (2019, 629) note, "digital modes are not always appropriate. For example, some health care requires physical contact between patient and health professional".

[5] Given the restrictions that were in place due to the COVID-19 pandemic during this period, all interviews were conducted online.

Table 2. Main interview topics

Topic guide	
What is your opinion about recent processes in rural development? What kind of trends can be observed?	What do you think about smart rural development and the smart village concept? What elements should it contain?
How did you find out about the smart village concept?	Which developments serve the interests of rural areas the most?
Which policy framework has recently influenced rural development in Hungary?	How would you describe the vision of rural areas in terms of development policy?

of small settlements, consultants, and spatial planners describe their approaches to digital transformation and understand smart village and its implementation as part of their real-life experiences. The topic guide was sent to the interviewees who requested it before agreeing to participate in the interview.

Specifically, the selection of some experts was based on their known national status in the field of rural development and their prior participation in (inter)national projects or in decision making. They have a high-level overview of the topic, as well as special knowledge and experiences based on their functions or responsibilities. Further experts were selected by snowball sampling, that is, existing study subjects recruited future subjects from among their acquaintances. Amongst the respondents, a representative of the Digital Welfare Programme should be highlighted, who were selected with the aim of gaining an overview and understanding of governmental policies and plans, as well as a bottom-up perspective on policy developments by actors 'on the ground'. The length of the shortest interview was 45 minutes, the longest was 91 minutes, and the average duration of an interview was 59 minutes. Verbatim interview transcripts were closely (re-)read to distil the (implicit) assumptions that key actors hold about smart village development, as well as to identify the perceived tasks and challenges related to it. Finally, insights were considered from the online Civitas Sapiens 2020 Smart City conference in November 2020, where several sessions and panel discussions dealt with the issue of smart development and the launch of the DVP.

Towards smart(er) villages in Hungary?

The forming of the smart village idea

Rural areas cover 87 per cent of the territory and are inhabited by 47 per cent of the population in Hungary (Eurostat, 2018a); furthermore, the country is characterized by a fragmented settlement structure, with 76 per cent of the 3,152 settlements having less than 2,000 inhabitants (Gáspár, M. 2019). The problems that these rural areas have faced – migration of the active well-trained labour force, depopulation, unfavourable age structure and high unemployment rate – are in many respects comparable to those of rural areas in other parts of Europe (Csotó, M. and Herdon, M. 2008).

The idea of addressing these problems by harnessing ICTs has already been present in the series of strategic documents (*Table 3*) that have served as the backbone of Hungary's digitalisation agenda, which seeks to ensure the country's alignment with Digital Agenda for Europe (European Commission, 2010c).

The *National Information and Communication Strategy 2014–2020* (NICS) (Government of Hungary, 2014a, 14) mentioned that ICT investments may help rural areas integrate and improve quality of life. Subsequently, the 'Digital Welfare Programme 2.0'[6] (DWP 2.0), which set the aim of ensuring that "every citizen and business of Hungary and

[6] In some instances, the Programme is referred to as 'Digital Success Strategy'. The present paper translates the middle term of the original Hungarian title (*jólét*) as welfare. It should be noted that *jólét* also signifies 'well-being' as well as 'prosperity'.

Table 3. Overview of rural development related policy initiatives and organisations

Scheme of relevant policy initiatives	
EU level	National level
Digital Agenda for Europe	Digital Village Programme (DVP)
Europe 2020	Digital Welfare Programme (DWP)
Common Agricultural Policy (CAP)	National Information and Communication Strategy (NICS)
–	New Hungary Rural Development Programme
–	National Digitalisation Strategy
–	Hungarian Village Programme (HVP)
Scheme of organisations	
European Innovation Partnership for Agriculture (EIP-AGRI)	Digital Welfare Non-profit Ltd.
European Network for Rural Development (ENRD)	Digital Future Settlement Network (DFSN)
–	Civitas Sapiens Smart City Knowledge Centre (CS Knowledge Centre)

the Hungarian national economy becomes a winner of digitalisation" (Government of Hungary, 2017, 3), asserted that government was "committed to the development of smaller settlements and lagging areas" (Government of Hungary, 2017, 121) and argued in favour of extending the notion of 'smart' beyond cities to 'smart areas' (ibid.). Nonetheless, despite the occasional occurrence of 'smart settlement' – also in the series of documents making up 'the smart city methodology' (http://okosvaros.lechnerkozpont.hu/hu) of the Lechner Knowledge Centre, the background institution of the Department of Spatial Planning and Urban Management of the Prime Minister's Office in the fields of architecture, spatial planning and related IT services – ICT use in the policy discourse of spatial development and public administration has remained dominantly framed in terms of the 'smart city'. The 2017 revision of the 2012 government decree on local-level planning contained a definition of the smart city[7], and the first government pilot (in the town of Monor) aiming at the development of a central platform for smart services has been referred to as a smart city pilot.

The first steps aiming to extend the smart development discourse to include non-urban areas were initiated by a handful of municipalities. Led by the town of Budaörs and the village of Alsómocsolád, they set up the Digital Future Settlement Network (DFSN) in 2016 to create a community platform for the testing and upscaling of inclusive smart projects and the exchange of best practices. Yet, it was the promotion of the smart village concept by the EU's policy discourse that created more publicity for the topic. Arguably, what played a role was also that it was Tibor Szanyi, Member of European Parliament for Hungary who – along with his Slovenian colleague Franc Bogovič – assumed a key role in starting the Smart Villages for Europe movement[8] in 2018. Confirming the government's commitment to the development of (small) rural settlements, in November 2020 the 'Digital Village Programme' (DVP) was

[7] Following this definition, smart cities are those 'settlement(s), or a group of settlements, which develop(s) its natural and built environment, digital infrastructure, and the quality and economic efficiency of its locally available services by adopting novel and innovative information-technologies, in a sustainable way, through the increased involvement of its residents' (Hungarian Gov. Decree No. 56/2017 [20.03]).

[8] Furthermore, perhaps not unimportantly, Tibor Szanyi, then member of the opposition Hungarian Socialist Party, argued that a key motivation for his initiative was that the Hungarian government had not done enough to reverse depopulation and the brain drain from rural to urban areas.

launched in order "to effectively facilitate the improvement of the attractiveness and liveability of small settlements with different digital or smart solutions" (https://digitalisjoletprogram.hu/). The DVP is directly related to the Hungarian Village Programme (HVP) and the DWP. Introduced in 2019 and fully financed from the central state budget, the aim of the HVP is to keep quality of life in villages as high as possible in order to maintain or increase populations in rural areas; more specifically, the HVP's aim is "to reinforce the capability of places with a population of less than 5,000, representing more than 30 per cent of the total population and more than 91 per cent of cities and villages, to retain their population, as well as to support housing opportunities in the countryside of Hungary" (Government of Hungary, 2020, 23).

The embedding of the DVP in the DWP is ensured through the supervision of the DVP by the Civitas Sapiens Smart City Knowledge Centre (CS Knowledge Centre), a division of the Digital Welfare Non-profit Ltd. (DWN Ltd.) operating under the auspices of the Ministry of Technology and Innovation. The CS Knowledge Centre, which sees itself as an "agile developer that makes the move from academic thinking on smart development to implementation" (interview, CS Knowledge Centre representative) has also been responsible for elaborating the structure of the programme (see *Figure 3*).

At the moment of writing (December 2020), only one project has been fully put in place: the free online self-study training in digital area development targeting decision-makers and practitioners in towns and villages. The long-term aim and objective of the training is "that every settlement has at least one expert who has accomplished the training and who, thus, can effectively contribute to the operation, digitalisation and smartening of his/her own village and of neighbouring towns and villages" (https://www.edutus.hu). Furthermore, the CS Knowledge Centre offers a 'settlement survey' which is meant

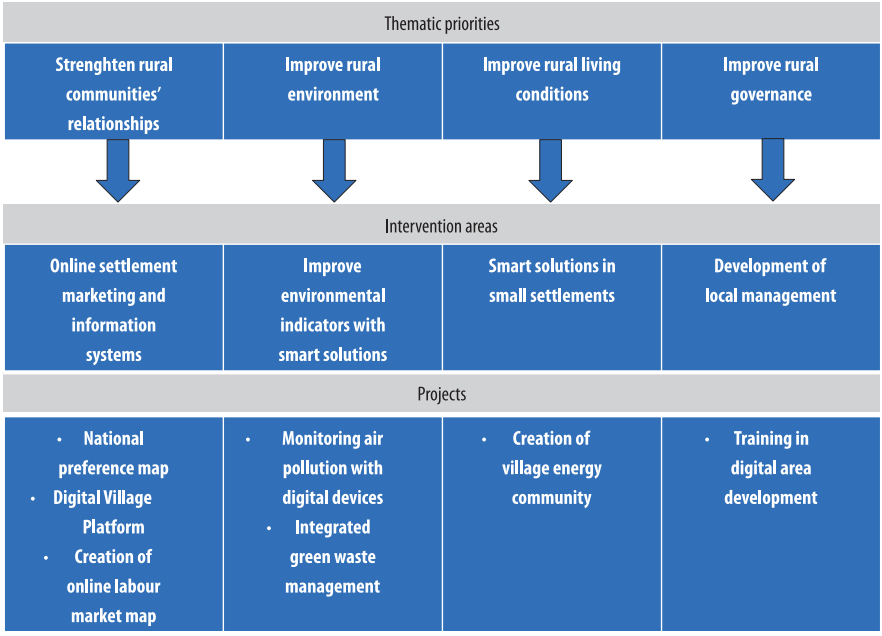

Fig. 3. The structure of the Digital Village Programme. *Source:* Authors' own elaboration based on conference material.

to reveal, based on the analysis of statistical data, existing planning documents and participative research (including in-depth interviews with key actors and local opinion makers), the state of digitalisation and aspects of local ICTs use, in order to sketch a local 'problem map'. Subsequently, reflecting on local needs, proposals are made by the Knowledge Centre concerning the improvement of municipal management, including suggestions concerning the use of specific products and services from the 'smart city marketplace' (to be launched early 2021), a centrally managed platform for the assessment, quality control and validation system of smart city products.

While the DVP is yet to be implemented, small settlements eager to harness the opportunities offered by digitalisation have continued to seek collaboration at different scales to take steps on their own. The already mentioned village of Alsómocsolád participated in the Pilot Project on Smart eco-social villages (2018–2019), initiated by the European Parliament and ECORYS, along with four other villages forming the North Hegyhát Micro-Regional Union (NHMRU), has set the aim of forming Hungary's first smart area. The Union, which has also joined the European Smart Village Network[9], published a detailed strategy that puts great emphasis on community participation and stresses the need to combine technological innovation with social and economic innovation (Északhegyhát Mikrotérségi Unió, 2019).

Assessing the prospects of smart(er) villages

Given that the DVP has only been recently launched and it is still taking shape, only a preliminary assessment of its prospective impacts can be given. However, based on the analysis of the declared objectives and instruments of the Programme, as well considering the perception of it by local stakeholders, some weaknesses can already be identified that make the shift towards smart(er) villages and to smart rural development, understood as a bottom-up form of governance, questionable, or in any case difficult in the short term.

First, the DVP does not address the (long-standing) lack of synergy between the weakly positioned non-sectoral part of rural development policy on the one hand and digitalisation policies primarily geared towards the improvement of digital connectivity and skills in rural areas on the other. As to the former, the failure of the EU's Common Agricultural Policy (CAP) to move away from being mainly an agricultural funding policy towards effectively addressing environmental and socio-economic challenges (Pe'er, G. *et al.* 2020) has been exacerbated by domestic political choices in Hungary. Like other Central Eastern European countries, the country's EU membership strengthened the position of agricultural lobbies and turned Hungary into a stronghold of industrial agriculture (Augustyn, A.M. and Nemes, G. 2014). The focus on agricultural production and the food industry has deepened rural inequalities rather than tackling them (Farkas, J.Zs. and Kovács, A.D. 2018). The agricultural focus remained strong in the 2014–2020 period, as Hungary's Rural Development Programme prioritized agricultural development and decreased the available funding for rural development (Finta, I. 2015). The relative stronger position of the agricultural sector is also apparent from the fact that under the DWP, a Digital Agricultural Strategy has been issued. Furthermore, rural development strategies – for example, the New Hungary Rural Development Programme (Government of Hungary, 2014b) – tend to mention technological renewal and ICT use in relation to agricultural production. Finally, even within the (marginal) section of rural development that was not defined in sectoral (that is, agricultural) terms between 2014 and 2020 (only 5% of the funds were used for LEADER purposes, see Finta, I. 2015), one could observe little if any direct concern with aspects of digital-

[9] The Smart Village Network is a bottom-up initiative of villages and village associations across Europe that aim to exchange their views and experiences about smart solutions in response to rural challenges (smart-village-network.eu).

isation, as (EU) funding was primarily made available for local economic development and community-building. The same holds for domestic funding for rural development, as the focus of the HVP is on basic infrastructural investments and public service provision.

Considering digitalisation policies, in line with the EU's Digital Agenda, they have regarded digitalisation as one of the key driving forces of competitiveness, growth and welfare and, despite some references to rural areas (see above), they have shown less concern with the actual spatial development implications of digitalisation (Varró, K. 2019). The National Digitalisation Strategy[10] (Ministry for Innovation and Technology and Ministry of the Interior, 2020), the objectives of which have been formulated in response to the EU's latest Digital Economy and Society Index report[11] of Hungary (European Commission, 2019), lays the focus on efforts in the field of the economy, education, and public administration that promote the country's competitiveness and the well-being of its inhabitants. References to rural areas in the document are restricted to remarks on the spatial patterns of FTTx (broadband network architecture using optical fibres) coverage and on internet use by, and the digital skills of, the rural population.

Second, state centralizing tendencies have prevented the development of a bottom-up integrated approach and the forging of inter-municipal cooperation, both of which are is regarded as prerequisites of successful smart village development (see Zavratnik, V. *et al.* 2018, and Spicer, Z. *et al.* 2019, respectively). State centralization has been characteristic of the whole post-1990 period. However, since 2010 the trend has intensified, leading to a loss of competences and financial and discretionary freedom at the municipal level (Pálné Kovács, I. 2019). This in turn further reinforced the external funding dependence of (especially smaller) municipalities.

Third, the dominantly top-down character of both rural development and digitalisation policies has also unfavourably affected the prospects of smart village development. Following EU accession, the LEADER programme – characterized by a bottom-up approach and a focus on local partnership in planning and implementation – was welcomed in Hungary by many as a method that would allow the catching up of backward rural regions (Patkós, Cs. 2019). However, bottom-up processes encountered strong resistance from central institutions and the public sector at the local level (Augustyn, A.M. and Nemes, G. 2014). Strengthening central state control has limited the room for implementing a bottom-up approach to rural development. In the 2014–2020 programming period, the LEADER method was extended under the broader term Community-Led Local Development (CLLD), but Hungary chose to limit the institutionalisation of CLLD to the obligatory 5 per cent within the overall rural development budget (Finta, I. 2015). The ability of LEADER local action groups (LAGs) to co-ordinate local forces and channel them into development programmes through governance remained at a low level, due in part to frequent changes in institutional structures and bureaucratic burdens (Patkós, Cs. 2019). Moreover, lengthy and rigid procedures and the punitive attitude of national authorities have hindered local experimentation and innovation and have contributed to a loss of trust. Coupled by the decrease in the volume of available of funding, the networking and project generating capacity of LAGs has diminished (Nemes, G. and Magócs, K. 2020). Against the background of the above trends, respondents have expressed doubts that settlements can take development into their own hands; referring to the DVP, one of them noted that most likely that will be just as centralized as the HVP (interview with spatial planner at international organisation).

A centralizing attitude has also permeated digitalisation policies. Although large-scale ICT infrastructure developments arguably warrant a centralized approach, the Digital

[10] The National Digitalisation Strategy has replaced the NICS.

[11] The European Commission has been monitoring Member States' digital progress through the Digital Economy and Society Index (DESI) reports since 2014.

Hungary programme has often not sufficiently considered existing local capacities and knowledge. For example, the establishment of a network of 1,500 'Digital Welfare Programme Points' (internet access points) did not build on the legacy of the telecottage movement[12] that played a pioneer role in introducing ICTs to rural areas (see Kovács, G. 2001). Even more importantly, the DVP does not seem to take notice of the experiences of existing bottom-up initiatives of smart village development such as that of the he DFSN and NHMRU. Despite the rhetorical emphasis on the involvement of inhabitants, the CS Knowledge Centre represents a centralizing approach, where the smart city marketplace is meant to ensure that "(local) solutions don't diverge from the state's efforts" and to prevent situations arising in which "municipalities spend money unnecessarily" (interview with CS Knowledge Centre representative).

Discussion and concluding remarks

In Hungary, the interest in smart village building is rooted in long-standing efforts to improve the position of the rural population. Meanwhile, the increased concern with digitalisation at the supranational and national scales has given a new impetus to attempts to harness ICTs for rural development ends. In line with the dominant policy discourse in Europe, the smart village has been promoted as a locally led and holistic approach that combines social and technological innovation to address the challenges faced by rural areas. Undoubtedly, the smart rural development policy field is still taking shape in Hungary, and there might be promising initiatives. However, the latter appear to be sporadic illustrations of the role of local innovators (mostly mayors), and they have difficulties scaling up successful interventions. Overall, our analysis reveals that path-dependent structural obstacles to bottom-up integrated development – such as the lack of (supranational and national) cross-sectoral policy coordination and the weak(ening) position of the local vis-à-vis other scales – present considerable obstacles to realize smart villages in the above sense. Ongoing pressures to align with EU policy frameworks and performance targets, coupled by centralizing measures – which have been further reinforced in the course of the COVID-19 pandemic – continue to represent an obstacle to local capacity-building and reinforce the funding orientation of small settlements and their focus on maintaining basic infrastructures.

Digitalisation policies, while increasingly including spatial development considerations, seem to remain primarily geared towards creating a 'digital state' where ICTs contribute to the effective and competitive functioning of the state. Although there is a rhetorical emphasis on the need to make smart development people-centred, the dominantly user-centred view of inhabitants and the assumption that the 'social validation' of ICT use is to be defined on the national level ("the question is, can a development be justified in Hungarian society?", interview, CS Knowledge Centre representative) implies that little room is left for genuine bottom-up citizen engagement and, thus, also for social innovation. While the lack of human resources and local knowledge might warrant a role for the central state in smart rural development, arguably, this should take a more a facilitating form and apply a long-term perspective. As a respondent noted, "these communities should be allowed to develop at their own speed […] central power should play an enabling role and supply them with information and knowledge" (interview with mayor). However, in its current top-down form ("it is an absolutely technocratic approach that reigns", interview with consultant), there is a risk that the DVP will be biased towards technological development. It will be a task for future research to confirm whether this is in-

[12] Telecottages functioned as hybrid (NGO-small business-municipal) organizations (ibid.) from the mid-1990s, and they have been conceived of as multifunctional public spaces offering a variety of technological, organizational and personal services tailored to the needs of local communities (Gáspár, M. 2016).

deed the case, and to what extent Hungarian policy developments fit the ideal-typical 'European' model of smart village building, or whether they show more similarities with a top-down approach applied elsewhere (e.g. in China, see Zhang, X. and Zhang, Z. 2020).

However, the juxtaposition of top-down and bottom-up approaches can easily lead to the formulation of a false dichotomy. In the context of globalisation, the situation of rural areas should be seen from a more complex relational perspective. Building on the argument of Massey, D. (2005) that local places are not passive victims of, or spatially fixed sites of resistance to, globalisation, there is a need to acknowledge that the character and development of rural places is determined by how local actors engage with global networks and processes, and as a result, how these places are constantly reconstituted, that is, the process of rural place-making is determined by both local and global forces (Woods, M. 2007). From this point of view, an analysis of power geometries and the changing roles of the state and development policies is of utmost importance. In the era of globalisation, the legal monopoly of the state in the regulation of spatial processes is weakening, and new normative systems are emerging at both supranational and subnational levels. Consequently, legal pluralism has become the norm, and normative systems operating at various territorial levels are key to determining the patterns of regional and local differences. State regulation, however, continues to have important functions, especially when other forms of regulation create and perpetuate socio-economic inequalities (Kondor, A.Cs. 2010).

Taking a relational multiscalar view on the production of local places and regional development has relevant implications for rural policies. In the age of globalisation, neither exogenous development models, driven from outside/above, nor purely endogenous approaches, based solely on local resources, seem to be realistic options for the development of rural (especially remote) areas. Instead, as several scholars argue, a hybrid neo-endogenous development model needs to be adopted. While neo-endogenous development emphasises the importance of local actors and resources, this does not mean that national- and regional-level actors should not contribute to the process. The main aim of this model is to develop long-term partnerships and cooperation between social actors at different territorial levels and with different needs. The role of the state lies in capacity building and in facilitating cooperation with local stakeholders. In addition, all these activities should be integrated into a broader rural policy and carried out in line with sectoral policies (Shucksmith, M. 2010; Gkartzios, M. and Scott, M. 2014; Bosworth, G. *et al.* 2016; Gkartzios, M. and Lowe, P. 2019).

In more general terms, the findings of this paper show that smart village research should not limit its focus to the assessment of local conditions, and it should not be conceived in narrow solutionist terms. Rather, and despite its (partly) different empirical focus, smart village research can usefully draw on critical smart urbanism (Verrest, H. and Pfeffer, K. 2019) to acknowledge the multiscalar and political nature of smart village development. Smart rural futures might indeed need to be framed differently from smart cities research (Cowie, P. *et al.* 2020), but both smart rural development and smart city development are shaped by shifting (spatial) forms of state power and governance in the digital age. A political-economic perspective allows for a more comprehensive assessment of the potential of smart village practices to address rural development challenges. It should, thus, be included in the repertoire of smart village scholarship.

However, there is a need to strengthen the links between small rural towns and villages, as current policies do not pay enough attention to coordinating the development of different categories of space. In the future, more emphasis should be placed on communication, with the aim of familiarizing the community with the various aspects of smart development and its potential everyday benefits. In this way, future developments can be made known and acceptable to the

community. For this reason, the successful implementation of pilot projects, the exchange of experiences and the projects implemented during the EU development period 2021–2027 will be even more important. Still, it appears that the approach calls for making the current financial instruments more flexible and tailored to EU and national scales.

Limitations

The course of the research was influenced by the COVID-19 pandemic situation in several ways: none of the expert interviews were conducted face-to-face, leading some potential interviewees from the corporate sector to pull out of the interviews. Given the pandemic situation and the fact that the Digital Village Program will enter the implementation phase from 2021, we did not gather field data, so this study outlines a conceptual framework and was not intended to present topic-specific empirical results. In the light of the above, a micro-level investigation of examples of the local implementation of the smart village concept could be a potential direction for future rural research.

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The concept of smart city and the perceptions of urban inhabitants: a case study from Žilina, Slovakia

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Abstract

The smart city concept is a comprehensive approach to the functioning of the urban region. It concerns various areas of life such as culture, infrastructure, environment, energy, and social services. Public perceptions of the smart city concept are not commonly addressed. The aim of this paper is to examine perceptions of the smart city concept among inhabitants, doing so through a case study focusing on the city of Žilina in Slovakia. The methodology that the researchers applied includes primary research and surveys as well as secondary research. Based on the analysis of the environment and the results of the survey, opportunities for the development of a 'Smart City Žilina' concept are identified. There is a growing interest in green solutions among the inhabitants of Žilina. A significant number of respondents indicated their support for intelligent waste collection and renewable energy sources. And they were also supportive of green roofs. The update of the strategy must consider a number of steps in waste management, from collection to transport, with a view to the overall recovery of the waste generated. As part of the smart city concept and projects, the public administration and the municipality must communicate effectively with the public. This will require specific approaches and tactical decisions for optimal success.

Keywords: Smart City concept, case study, perception, inhabitants, public administration, communication

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Introduction

The issue of smart cities has been addressed in the last decade in many forums. The concept is gaining more and more importance and comes to the fore not only in terms of scientific research itself, but also in terms of the application of its results. This trend follows the growing urbanization and the increasing proportion of the population living and working in cities. As the urban population share increases, many of the challenges facing urban management can be identified. Smart city has many dimensions and touches on the need for a more interactive and faster city administration and safer public spaces. The concept of smart city mainly affects the quality of life of the city's inhabitants, and the criteria by which it can be measured include: quality of the working environment, possibilities to buy goods and services, leisure time, sense of social security, personal development, physical quality of the environment, economic development and housing and the possibility of participating in public life.

The smart city concept is therefore a comprehensive approach to the functioning of the urban region, which extends to different areas of life such as culture, infrastructure, environment, energy, social services and more. Each of

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these areas pursues several objectives which are interrelated and jointly create a system based on the principles of sustainable development. Public administration, the private sector and civil society enter this system, without which the set objectives would not be met.

EU cohesion policy for the period 2021–2027 also emphasizes the strategic goals of a smarter Europe, green solutions, a connected and social Europe that is closer to the citizen and supports local development strategies and sustainable urban development (New Cohesion Policy 2018). It emphasizes the citizen and his / her environment, which will improve his / her life, living conditions and sustainability. Therefore, it is also important to examine how citizens perceive individual smarter, green, sustainable and renewable solutions that are prerequisites for the fulfilment of the strategic objectives of EU cohesion policy. Public perceptions of the concept of smart city have rarely been investigated by researchers. This paper focuses on the perceptions of the smart city concept among inhabitants of Žilina in Slovakia. Applying the principles of smart city in a specific location evokes several research questions:

– Do the inhabitants of the city know the concept of smart city and its connection with other functionalities of the city and its life?
– What do citizens consider crucial for improving living and business conditions in the city?
– How are the benefits of projects implemented under the concept of smart city and what is important in the concept from the perspective of different segments of the population and visitors to the city?

The paper reports on research results of a case study within the city, which has about 80,000 inhabitants, but which represents, in a broader sense, the centre of a region with about 600,000 inhabitants, including attractive destinations for domestic and foreign tourism, are presented in the rest of the paper. Subsequently, recommendations concerning the public communication of the smart city concept are given. The recommendations may be of benefit to the administration of the city or they may facilitate the operation of individual smart components of the infrastructure.

Theoretical background

In urban development, a modest rise of creativity started during the 1980s. The mid-1990s saw the emergence of the creative city concept. At the beginning of the 2000s, the creative economy and the cult of creativity rapidly spread around the globalizing world. After the crisis of 2008–2009 the smart city concept came to the focus of attention (Egedy, T. 2017). Since then, globalization has been reshaping national economies by extending market conditions and competition around the world. A profound transformation in the nature and conditions of competition resulted in a policy of deregulation (Erdeiné Késmárki-Gally, Sz. *et al.* 2015), therefore, regional and local initiatives have been gaining increasing impetus and importance worldwide. Of these initiatives, environmentally friendly, sustainable and citizen-friendly solutions aimed at modernizing of urban areas, combined with the implementation of state-of-the-art technologies ('smart cities'), need to be identified as a relatively new phenomenon.

According to the Smart City Dictionary, the smart city concept represents an urban development vision that integrates information and communication technology (ICT) and the Internet of things (IoT) technology in a secure way to manage a city's assets. According to the Business Dictionary, smart city is a developed urban area that creates sustainable economic development and a high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living and government. It is possible to excel in these key areas through strong human capital, social capital or information and communication technology infrastructure. Of the many options available, the British government's inspirational approach can be considered (Department Business, 2013). It states that the concept of 'smart city' is dynamic and that there is no absolute definition of a city that is smart. The concept is endless and is rather a process or a series of steps that make cities more habitable and resilient and, thus, able to respond more quickly to new challenges.

A detailed analysis of literary sources in relation to smart urban governance is given by Meijer, A. and Rodríguez Bolívar, M.P. (2015), who emphasize the multidisciplinary nature of the subject of smart city. Definitions of smart cities usually focus on three key topics, namely technology, people and governance in the city and subsequently on their interactions (see also smart cities dictionary and definition). It has also been claimed that the key elements of national and regional e-tourism strategies in the Carpathian Basin need to be analysed in the broader framework of ICT strategies for development (Dávid, L. and Szűcs, Cs. 2009), while Zimányi, K. *et al.* (2014) discussed the new forms in the online sales in commerce and tourism.

According to the Web of Science and Scopus databases and according to the subject of the solution, literary sources on smart city are predominantly assigned to technological areas - electrical engineering, engineering, ICT and their applications. The smart city definition by Jia, Q. and Xu, C. (2021) is connected with the combination of advanced sensors to manage the city´s assets and the information technology virtually. Mossberger, K. and Tolberg, C.J. (2021) also state that "over the past decade, the vision of smart cities filled with technological innovation and digitally engaged citizens has been pursued around the globe, but not all city residents have a chance to participate in or benefit from these innovations". McQuire, S. (2021) argues for the need to decouple thinking regarding the potential of urban digital infrastructure form the narrow and often techno-centric discourse of ´smart cityism´. Such a decoupling will require continued experimentation with both practical models and conceptual frameworks but will offer the best opportunity for the ongoing digitization of cities to deliver on claims of ´empowering´ urban inhabitants.

Regarding geography, urban studies and urban and regional planning, about 10 per cent of all the records fall in te field in both databases. The increase in smart city publications in the last decade has been enormous. It represented up to 98 per cent of the total number of publications on the topic of smart city. Overall, Smart City is a city where the traditional system of urban infrastructure and services is enhanced by modern digital and telecommunications technologies.

One may ask why only in cities and not in rural areas? Smart villages are a rarity, particularly in Central and Eastern Europe. The answer may also be simple, as the gap between living conditions in urban and rural areas is still too large, despite the EU-funded cohesion projects. A survey in the South Moravian part of Czechia showed that almost a fourth of municipalities support commercial trade and services, mainly through subsidies or lowered rent. Even simplifying red tape or providing tax relief would help to support civic amenities, but another key development would be retaining young and educated people in municipalities where they will live and work (Šilhan, Z. and Kunc, J. 2020). An important question was raised in relation to Hungary (but probably it relates to the entire CEE region), namely whether the digital divide follows the industrial divide in the economic space or not (Kiss, É. and Nedelka, E. 2020).

Many definitions consider smart city as well as intelligent city as a one-way approach to communication, and therefore decision-making on individual projects that make up smart city is not an optimal choice (Rechnitzer, J. *et al.* 2019). It should not be a top-down or a bottom-up approach, but one based on cooperation, with communication in all directions (Dado, M., Zahradnik, J. *et al.* 2007). It is not enough for people to have access to information; a further requirement is for information to be created.

Each smart city is characterized in particular by the following features:

– *Smart economy* – innovation, entrepreneurship, economic image and brands, productivity, labour market flexibility, international attractiveness.
– *Smart mobility* – local accessibility, national accessibility, availability of information technologies and infrastructure, sustainability of the transport system.

– *Smart conditions for life* – cultural facilities, health conditions, individual safety, quality housing, school facilities, tourist attractiveness, economic prosperity.
– *Smart governance or administration, management systems* – participation in public life, public and social services, transparent administration.
– *Smart environment* – environmental conditions, air quality (no pollution), ecological thinking, sustainable use of resources.
– *Smart citizen* – level of acquired qualification, lifelong learning, ethnic plurality, free will (http://www.smart-cities.eu).

It is necessary to mention the six-axes model of Cohen, B. (2012), who identified smart cities by six main dimensions *(Figure 1).* The model is frequently cited in the international literature. Examples include Soe, R.M. (2017), who reflected on examples in Estonia and Finland, and Dobos *et al.* who developed a methodological recommendation based upon positive examples in the world including Helsinki, Copenhagen, Ljubljana, London, Amsterdam and Vienna (Dobos, K. *et al.* 2015).

The axes of Cohen's model are: smart economy – smart mobility – smart environment – smart people – smart living – and smart governance. These six axes formulate links with traditional regional and neoclassical theories of urban growth and development.

In addition to these cities, there are many smart city projects or smart city initiatives in the world, especially in developed countries. In South Korea, the example of Songdo city can be mentioned, a new settlement which was established in the early 2000s, and the smart city project was launched during the tenure of former president Lee Myung-bak (2008–2013), who supported the idea of environmentally sound and sustainable urban development with low carbon-dioxide emissions. The costs of the project amounted to around 40 billion USD, with several multinational companies and local authorities working together in a PPP (private public partnership). The aim was to develop a sustainable settlement and a viable international economic centre (Czirják, R. 2016).

In Hungary a number of towns and cities have implemented smart city-sound development projects. However, some of these projects have been placed in this category in view of the advantageous funding possibilities, while in other cases the objectives were more complex and well elaborated, especially in the field of public utility development (Tóth, G. *et al.* 2013). The settlement evaluation system in Hungary comprises six major criteria – smart mobility – smart environment – smart people – smart living – smart governance – smart economy. These criteria are further divided into sub-categories and

Fig. 1. The smart city wheel by Cohen, B. (2012)

also relate to the respective Cohen-indicators (Dobos, K. *et al.* 2015)

The smart city uses new technologies, including information and communication technologies (ICT), to increase the quality and performance of urban services, reduce costs and resource consumption, and involve its citizens more effectively and actively in city life (see Vaculík, J. and Tengler, J. 2012). Sustainable development in particular is the basis. This development of human society is one that reconciles economic and social progress with the full preservation of the environment (Madudova, E. and Dávid, A. 2019). A major goal of sustainable development is to preserve the environment for future generations. It is based on the social, economic and environmental pillar (Kalašová, A. 2012).

The introduction of the concept of a smart city brings several benefits. Among the benefits of smart cities, we can include**:**

- Increased level of functionality of the city: employment opportunities, access to basic aspects of prosperity - to infrastructure services such as interconnection and connectivity; reliable, sustainable and low-cost energy sources; adequate training opportunities; affordable forms of housing and efficient transport.
- Sustainability: is a method by which resources are not depleted or permanently destroyed. Sustainability is not only about the environment, but also about the economy. Smart cities make efficient use of natural resources, economic resources and human capital to create their urban infrastructure that delivers the highest possible outputs and costs as few inputs as possible.
- Raising inhabitants' living standards: access to a comfortable, healthy, clean, safe and active lifestyle, which includes several aspects such as cheap energy sources, convenient public transport, quality education, faster public services, clean water and air quality, low rates crime and access to various entertainment and cultural opportunities (Smart City 2014).

Important features of the smart city are, therefore, a cooperation economy, a shared economy, a green economy and a circular economy (Matúšková, M. and Madleňáková, L. 2016). These represent changes in the social paradigm of the position of people in society in the 21st century, who do not need to own items of daily consumption and are able to use common products thanks to various communication tools (Turská, S. and Madlenáková, L. 2019). People or organizations share the resources at their disposal that they do not make full use of (e.g. cars, infrastructure). They collaborate and reuse in the context of sustainability and environmental protection (Woetzel, J. *et al.* 2018). This concept embraces four basic elements:

- transport, e.g. sharing of vehicles, bicycles, public transport;
- energy, e.g. concepts of shared electricity generation;
- public space, e.g. sharing investments and activities in joint projects;
- social, e.g. sharing of living space, catering, etc.

We can say that the concept of a smart city and a sharing, collaborative or circular economy lead to the decentralization of political and economic power, to economy and to a conscious behaviour towards the environment in which we live.

Each city is unique and faces its own problems that it must solve. For this reason, it is questionable, whether one can assess which city or which country is currently the smartest. However, there are several rankings that try to answer this question. The best known are the Cities in Motion Index, the IMD Smart City Index and the European Smart City Model. The Cities in Motion Index evaluates cities in terms of ten areas. The IMD Smart City Index includes citizens' perceptions among the evaluation criteria of smart city levels. Citizens' perceptions, on the other hand, are balanced by economic and technological aspects.

The European Smart City Model (European Smart Cities 3.0 Home) provides an integrated approach to defining the profile and comparing medium-sized European cities and can be seen as a tool for effective learning in the field of processes related to urban innova-

tion in specific areas of urban development. Cities according to the model are divided into two groups according to the number of inhabitants. In the first group there are cities with a population of 100,000–500,000, in the second group 300,000–1,000,000.

Within Slovakia, however, only two cities currently belong to these categories, namely Bratislava, the capital of Slovakia, and Košice. Other regionally important cities have less than 100,000 inhabitants. Based on research by Giffinger, R. and Haindlmaier, G. (2010), eight Slovak cities with a population of 50,000–100,000 were evaluated using a smart city index that includes 6 mutually relativity independent areas and a total of 31 relevant factors. None of these cities were the best in all areas. Overall, the best rankings in 2020 were achieved by Banská Bystrica, Nitra and Žilina *(Table 1).* Other cities have lagged significantly behind. Based on these values, we decided to pay more attention to the city of Žilina in terms of citizens' perceptions of the smart city concept.

Smart cities are, thus, a developing segment of the market with innovative solutions, which, however, are not an end in themselves, but a means to increase the quality of life in cities and to improve the business environment.

Aims and methodology

The aim of the paper is to examine perceptions of the smart city concept among the inhabitants of the city Žilina in Slovakia. The research methodology was based on an analysis of secondary sources from the point of view of the concept of smart city according to Cohen, B. (2014) and the Smart City Index (2020) and on primary research conducted through a questionnaire survey. The survey of perceptions of the smart city concept among inhabitants of the city was focused on finding out to what extent the inhabitants have knowledge of the concept, what they consider to be crucial areas that need to be solved within the city, and how they evaluate already implemented projects within the concept. The survey was conducted using a structured questionnaire. A pre-test was also carried out with five respondents. Based on that the method was slightly modified, and during the selection of respondents the concept of smart city was briefly introduced. The adjustment resulted from the fact that 4 out of 5 randomly addressed respondents did not know the importance of the smart city concept or confused it with a hard disk monitoring system that detects and sends reports on various reliability indicators in an effort to predict failures. The indicators must meet the criteria of S.M.A.R.T. – and must be *Specific, Measurable, Accessible, Realistic* and *Timely*.

The selection of respondents in the survey was random and included the public/residents living and/or working or studying in the city. Data collection and processing took place in March-April 2020, using a combination of personal (March 2020) and online (April 2020 due to anti-pandemic measures)

Table 1. Ranking of Slovak cities with 50,000–100,000 inhabitants according to smart city index in 2020

City	Population	Position	Smart					
			economy	people	governance	mobility	environment	living
Banská Bystrica	78,327	1	1	1	4	3	3	4
Nitra	76,655	2	4	2	1	2	1	6
Žilina	80,810	3	2	3	2	4	6	2
Poprad	51,304	4	7	8	7	1	7	1
Trnava	65,207	5	3	5	6	5	4	8
Trenčín	55,333	6	8	7	3	6	2	7
Martin	54,618	7	6	4	8	8	5	3
Prešov	88,680	8	5	6	5	7	8	5

Source: by Smart City Index, 2020.

inquiries. The questionnaire consisted of identification and merit questions. The survey examined the frequency of individual answers within closed questions. In selected questions, a multiple answer was possible, as well as an assessment of the significance of the elements. The unipolar Lickert scale (0–4) was used to assess significance. The formulation of meritorious questions followed in-depth interviews with employees of the city of Žilina, analysis of secondary sources and concerned individual areas of the city's strategy from the point of view of the smart city concept.

The methods used in this paper are clearly based on the application of analytical, synthetic and comparative methods that also represent recommended methods in the application of diagnostics and subsequently therapeutic methods in the process of the investigation of inhabitants' perceptions and expectations regarding the smart city concept and projects related to the smart city concept.

When determining the number of respondents in the survey, we based it on the current number of inhabitants living in the city of Žilina (in 2020 it is 80,810). We also set the reliability of the estimate at 95 per cent, with the maximum allowable error range being set at 9 per cent and the variability of the base set at 0.5. The total minimum number of respondents was set at 118 (Haľamova, E. 2020).

In terms of age structure, the largest group consisted of respondents aged 20 to 30 years (63 respondents, which is almost 54% of the total). The stated composition of the respondents also reflected the fact that this age group uses online connections more intensively due to the electronic form of the questionnaire. In terms of educational attainment, most respondents had a secondary education (60% of the total number), respondents with a university degree (30%) and respondents with a primary education (10%). The largest group, depending on gender, age and education, consisted of men aged 20 to 30 years with secondary education (19%). As part of the questionnaire survey, we were interested in the form of the respondent's stay or residence in the city of Žilina. As Žilina is a regional city and is considered the 'metropolis' of northern Slovakia, many citizens come to the city for various reasons. Of the total number, respondents with permanent residence in the city accounted for 62 per cent, over 26 per cent of them worked or studied in the city, and 10 per cent visited Žilina temporarily. The other respondents were either staying temporarily in the city or had come to the city to work or study.

Results of the case study

A major strategic goal of the city is to create the conditions for sustainable development. In other words, Žilina wants to be a city in which there are permanent conditions for the continuous optimization of the living conditions of both inhabitants and visitors. This aim is to be fulfilled in line with the natural and historical conditions of the city environment (www.zilina.sk). The city of Žilina, as the centre of the wider region, also directly cooperates with the Žilina self-government region (further ŽSK) and builds on several of its documents (ŽSK, 2015, 2016). In individual projects, it cooperates with other entities, including businesses, the University of Žilina and non-governmental organisations (NGOs) (Strelcova, I. 2016; Jesenko, M. 2017; SAD Žilina 2019).

Competences transferred from the central level of the state to the level of the city of Žilina under Slovak legislation, are in the following areas: transport and communications, social services, waste management, culture and tourism, primary education, local taxes, applications and issuing various permits for residents and institutions operating in the city, as well as the city's own management and emergency management. If we build on the theoretical definition of the concept of smart city according to Cohen, B. (2012) as well as by Smart City Index (2020), it is possible to identify certain positive solutions according to individual smart areas and based on an analysis of secondary sources of the city. An advantage for the city is the presence of

the university and several research institutes, which have long been dealing with transport issues, new technologies in transport, ICT, engineering, construction and energy. Selected municipal institutions are actively involved in several projects run by these institutions. At the same time, the university actively contributes to the elaboration of the city's spatial plan and to the shaping of transport policy. Of course, the city's zoning plan itself, as part of its updates, is influenced by new elements associated with smart solutions.

Smart mobility includes smart transport and so we identified technological solutions associated with smart public transport and traffic management (Strelcova, I. 2016; SAD Žilina 2019). From the perspective of public transport, the essence of smart traffic management in Zilina is important. Active communication board units are applied in vehicles with stop road traffic signal controller, which controls the crossing intersections to the current position. The system along with other traffic information is integrated into the software platform. This may be the mobile app Smart Žilina and the web smart.zilina.sk benefit residents and dispatchers transport company. Other smart mobility solutions include:

– a bike-sharing;
– an intelligent system for controlling access to the pedestrian zone, which contributes to a reduction of the number of vehicles in the pedestrian zone. The regulation of parking in city neighbourhoods is aimed at streamlining the use of parking spaces and at reducing the number of surplus vehicles.

Transport in Žilina in the context of smart mobility would be focused in future on complex regulation (e.g. the regulation of individual vehicles, public, bicycle and pedestrian transport, including the solution of static transport). The aim is to shift passengers from individual car transport to sustainable modes of transport.

Within the smart environment as a part of the smart city concept two projects, Airtitia and Solez, are being addressed. The city of Žilina is located in a basin with unfavourable geographical conditions in terms of the dispersion of emissions in the air. Reducing the burden of emissions in the urban environment has traditionally been among the priorities of the city of Žilina. Within the framework of Airtritia, measures have been taken to monitor air quality and to develop an action plan addressing critical levels of air pollution in the city. The project Solez enabled the city to develop an action plan for low-carbon mobility, introducing low-carbon measures, alternative means of transport and low-emission zones.

Smart conditions for life are connected with the smart energy infrastructure based on intelligent network elements, enabling the use of renewable forms of energy and regulating the behaviour of both producers and consumers. The growing number of cars on the road puts pressure on the use of cleaner vehicles, especially electric cars, and hinders shared mobility opportunities. The city also created an initial scheme for promoting health and improving the quality of life of citizens and visitors, with support being given to initiatives relating to human capital, education, social inclusion and citizens' cooperation. It finances its projects mainly using international grants, EU funds, the resources of the KIA Motors Slovakia Foundation and its own resources.

Efforts to improve the effective management of resources and to ensure adequate responses to the interests of citizens, social organizations, companies and administrations, led the city government to seek membership of the Smart Cities Club (membership was achieved in September 2019).

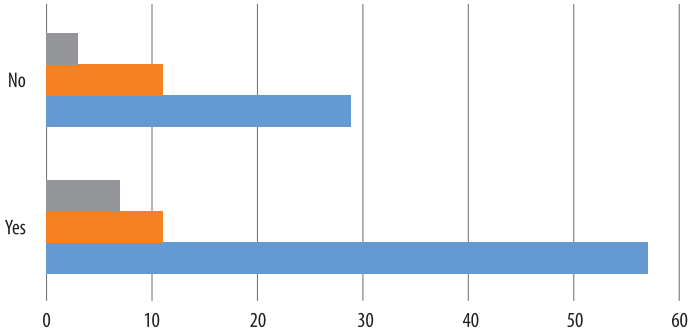
It can be stated that separate strategies for individual areas according to the concept of smart city have not yet been formulated at the city level. However, individual projects gradually contribute to the fulfilment of the concept. The projects touch on key areas in terms of the city - mobility and the environment. In these two areas the city of Žilina has a low ranking on the smart city index (see *Table 1*). In the area of smart people, the city of Žilina does not have all the competencies and needs to cooperate with the Žilina self-governing region (ŽSK) and the university, which operates in the city and has a much broader scope.

Similarly, in the smart economy, the city focuses on its own management and the exercise of its competencies in the field of taxes and fees, which determine the characteristics of the business environment in the city.

The findings of the primary research (Haľamova, E. 2020) are presented in the following sections of the paper. In terms of their perceptions of the smart city concept, respondents consider it primarily as a technological concept associated with the use of new modern technologies and especially ICT. When choosing the answers, they had three options, namely that they perceive the concept as a change in society, a change in the solutions used and the implementation of new technologies. 63 per cent of respondents chose one of these options. 70 per cent of respondents perceive the term 'smart city' to be associated with the use of modern technologies, while less than 10 per cent associate it with a 'change in society' *(Figure 2).*

In addition to knowledge of the concept of smart city and its connection with various changes, respondents commented on their knowledge of the city's investment in the concept. Respondents with a university degree are expected to have a higher level of knowledge. Also, some of the respondents' job descriptions may distort the findings, as some respondents work in the state and public administration. Our assumptions concerning respondents' job classifications were confirmed. Respondents with secondary education working in the state and public administration had the most knowledge about the city's investments in smart city. We found that up to 43 per cent of respondents did not know about investing in smart city, while 30 per cent of respondents think that the city does not invest in smart city. Based on the findings, it can be stated that most of the respondents do not have knowledge about investing in smart city, which reflects insufficient communication between the city and citizens. Only 29 respondents have knowledge about investments.

The perception of smart city as the use of new technologies proved to be essential, what the citizens themselves do not directly connect with changes in the city and society itself. Subsequently, the attention of the respondents was focused on the question of what they consider to be decisive or most important in terms of the future development of the city.

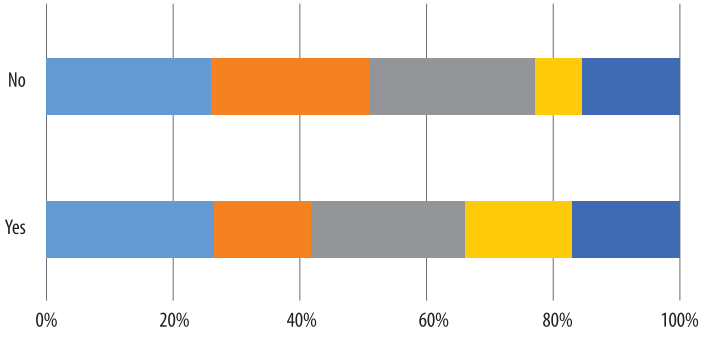


	Yes	No
Change in society	7	3
Change in approach to solution	11	11
New technologies	57	29

Fig. 2. Knowledge of the term Smart City and its connection with selected items. *Source*: Haľamova, E. 2020.

More than 26 per cent of respondents consider intelligent waste collection to be the most important area of the development. The second most important area of development according to respondents is the use of renewable energy sources (25% of respondents). Respondents consider the management of public lighting to be the least important area (12% of respondents). From a gender perspective, men consider smart waste collection and support for the use of renewable energy sources to be the most important areas for development, and only 8 men consider support for the construction of green roofs the least important area. Women also consider intelligent waste collection to be the most important; according to them the use of renewable energy sources is also important, and they also consider the construction of green roofs to be an important area. It is interesting in terms of stereotypes in Slovak society that women do not consider public lighting management to be an important area. It should also be noted that, in the 20–30 age group for both men and women, the promotion of renewables in particular plays an important role. For respondents over the age of 50, the results are different, with men promoting intelligent waste collection and support for renewables and women promoting green roofs. The comprehensive results obtained from the survey are shown in *Figure 3*.

This was followed by a survey of respondents' perceptions of individual sub-projects that were and are being implemented within the city and can be assigned to individual areas of the smart city concept. These projects in terms of secondary research include a bike-sharing system, a smart system for monitoring the entrance to the pedestrian zone, a smart public transport system connected with 'green' preferences at crossroads, the monitoring of air quality, e-services for communication between citizens and municipalities, and the establishment of a contact point for municipality services. The city of Žilina has implemented several projects within the smart city framework. The 'bike-sharing'



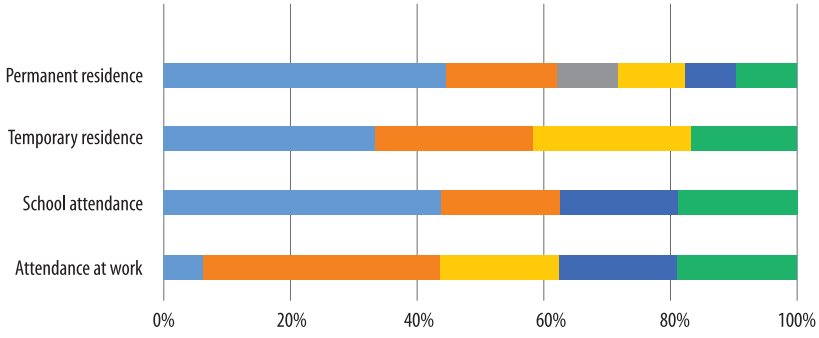
	Men	Women
Smart waste transport	14	17
Support for green roofs	8	16
Promoting the use of renewable energy sources	13	17
Public lighting management	9	5
City news	9	10

Fig. 3. Potential areas of the Smart City concept in *Žilina* by gender. *Source*: Haľamova, E. 2020.

system BIKEKIA is rated as the best project (*Figure 4*). As many as 38 per cent of respondents rate it as the best, while the project for electronic communication between the citizen and the office came in second place. Less than 6 per cent of respondents consider a smart system for regulating pedestrian entrances to be the best project.

In terms of the nature of respondents' stay or residence in the city, the BIKEKIA 'bike-sharing' system is rated as the best project in all groups of respondents (with the exception of commuters), while commuters consider a project promoting electronic communication between citizens and the office to be the best project. Respondents studying in Žilina showed indifference towards an intelligent system for regulating pedestrian entrances and a modern contact point for services for citizens. According to the questionnaire, only respondents with permanent residence in the city consider the regulation of access to the pedestrian zone to be the best project; other groups did not vote for the said project at all. In addition, respondents staying temporarily in the city did not rate the project related to air quality monitoring as the best project.

When determining the significance of individual areas of the smart city concept, it was possible to state more answers and mark their order. What is essential within the concept of smart city for citizens? Multiple answers were possible to the results of the survey in terms of the importance of the smart city concept. Respondents identified mobility as the most important part of the concept (24%). In second place there was the environment (20%) and in third place the city administration (18%). On the other hand, less than 5 per cent of respondents chose the field of sports and culture in terms of importance within the Smart City Žilina concept (*Table 2*).



	Attendance at work	School attendance	Temporary residence	Permanent residence
Bikesharing system BIKEKIA	1	7	4	33
E-communnication of the citizen with the city	6	3	3	13
Smart system for controlling the entrance to the pedestrian zone	0	0	0	7
Modern contact workplace for services for citizens	3	0	3	8
Air quality monitoring	3	3	0	6
Smart Public Transport	3	3	2	7

Fig. 4. The best project within the Smart City concept in *Žilina* depending on the respondent's stay in the city. *Source*: Haľamova, E. 2020.

Table 2. The essential areas within the concept of smart city with regard to age and gender

Respondent	Tourism	Energy	Mobility	Economy	Governance of city	Sport	Education	Environment	Culture	Total
Men, years										
20–30	–	7	15	6	13	1	7	13	–	62
30–40	3	7	7	2	6	–	2	5	2	34
40–50	1	1	1	–	2	–	–	4	–	9
50 +	2	1	1	–	1	3	–	–	–	8
Women, years										
20–30	6	9	22	4	8	1	6	16	3	75
30–40	2	6	8	3	9	1	3	5	1	38
40–50	–	1	4	–	4	1	–	6	–	16
50 +	–	2	2	1	2	–	–	1	–	8

Discussion and conclusion

Based on the primary and secondary research results, we focused on identifying opportunities for the development of the smart city Žilina concept. For the citizens of Žilina, as well as for students and employees, there is a growing interest in:

– Smart means of communication with the municipality;
– Waste management;
– Renewable resources;
– Green solutions. For example, a significant number of respondents consider support for green roofs to be a key area.

These are topics perceived by citizens as important. From the point of view of a smart city, the open communication of the municipality with all stakeholders, citizens and visitors can be fulfilled through the adoption of other solutions in the field of the environment. In this area, Žilina is ranked, based on the smart city index (see *Table 1*), in sixth place out of eight ranked places. Clearly, the challenge of creating a sustainable environment is also reflected in public perceptions of the importance of this area to the city.

Cities have yet to become aware of the urgency of these challenges and the need to implement the laws of Slovakia. Introduced in 2021, the legislation also covers the separate collection of waste in colour-coded containers.

The updating of the strategy must consider a number of steps in waste management, including separation and collection, with a view to the overall recovery of the waste generated. Further steps must be aimed not only at reducing waste costs, but also at improving the services provided to citizens from an environmental point of view. Although these solutions will require an initial investment, they will ultimately lead to improved services.

In our opinion, the feasibility of these goals in smart environmental policy may be achieved by 2030. Services in a real smart city should communicate with each other and make use of both their own technological data and municipal data (such as the databases of municipal authorities, transport

companies, water companies, schools and other municipal institutions). They should also draw on other data sources, such as public data from reference registers. A unified database would make it possible to build a wider portfolio of services at lower cost, as the interconnection of data sources is solved together for all services.

In connection with the development of a smart city, public administration institutions must focus their attention on:

– Connecting the target groups.
– Satisfied citizens, customers and transport users.
– Relations with workers, public service employees.
– Relations with the government, public sector, business sector, including lobbying.
– Relations with the media, the general public, 'belonging to ...', relations, membership, etc.

The following aspects should be especially highlighted:

– Public perceptions of individual measures. A positive perception of measures among the public has a decisive influence on the use of smart city technologies and services, as well as on the effectiveness of individual measures to ensure sustainability and, where appropriate, increase performance. It is necessary to work consistently with the public and influence its attitudes towards new solutions by explaining the benefits, etc.
– The impact on the sustainability of technical solutions. The application of smart city technologies and services is connected with the provision of routine operation and innovation of lower-order services, which require a thorough focus on the organizational provision of deployed innovative services.
– Systems and measures to ensure the quality of life in the city.

The impacts of the implementation of smart city projects must be assessed in terms of their life cycle (i.e. the impacts or effects of projects in the planning, evaluation and design phases, political decisions, construction or implementation and operation). For each impact, appropriate indicators must be used, and their interrelationships established. Changes in the city associated with the implementation of smart solutions can have a positive or negative impact on other parts of the region or locality. It can be assumed that positive impacts in one place will cause negative impacts in another place in the region – cities – localities. Therefore, there is a need to assess how the competitiveness of the urban part – localities – cities – regions changes (growth – decrease) in comparison with other localities – cities – regions and to compare the development in relation to the development in the whole state, in the national economy.

Communication within the smart city is quite specific and also requires specific approaches and tactical decisions for optimal success. Access to project information within the smart city needs to be coupled with an outline of the content and purpose of the project, explaining how the proposed solution replaces and complements existing solutions as perceived by the public. Positive perceptions crucially affect the use of technologies and smart city services as well as the effectiveness of various measures to ensure sustainability solutions. Proper marketing communication means to interpret the messages that describe the already existing solutions or should include research results without ties to the specific products or time data.

When addressing the issue of a smart city, partnerships are established by law with the aim of generating multiple benefits. Partnerships are essential in this area, but it should be borne in mind that they will have a major impact on marketing communications and public relations activities. If the partners agree, each communication activity gains added value and meaning. However, partners do not always have to share the same views and may have hidden intentions. Another problem may be the leakage of information, which can be prevented by the greatest possible degree of harmonization of partnership cooperation. The effectiveness

of applying the right approach and tactics depends on eliminating weaknesses in the partnership agreements and creating a solid foundation for the partnership.

When communicating with the public about smart solutions and the whole concept of a smart city, it must not be forgotten to whom the communication activities are aimed. The so-called target groups and communication tools are in the centre of attention. All messages communicated in the field of smart city must be attractive and comprehensible to the target groups and must correspond to their interests. A great or significant opportunity for the city of Žilina is the cooperation with the university and other research institutions, as well as non-governmental organizations focused on the development of non-motorized transport in particular in the field of smart mobility.

The transformation of the city into a smart city requires, above all, a systemic approach, which must be based not only on the vision and mission of the settlement unit but also on a common database when using e-services. However, in order to ensure the interoperability of e-services, the local government should, in accordance with the draft framework of e-services, rely on requirements developed both in Slovakia and at the level of the European Union. It is necessary to transfer the smart city strategy not only to the main strategic plan of the city, but also to the strategic plans of individual areas. Our findings on public perceptions of smart solutions are also a starting point and an opportunity for formulating strategic goals and tactical approaches of the municipality within the context of EU cohesion policy for the years 2021–2027. Smart solutions are not used to compete with other cities and to gain a certain position in terms of rankings. However, they provide inspiration for other locations and provide valuable information for the city management itself about the adoption of smart solutions or policies by citizens.

Support for smart cities and regions should be based on the cooperation of all stakeholders from the very beginning of the process, starting with the formulation of a vision, priorities and policy options and leading to the definition of specific measures. First and foremost, it is essential to inform and motivate all stakeholder groups, with a view to facilitating joint efforts aimed at developing a concept or strategy of effective cooperation. Civil society needs to be involved in the process, as active citizens can initiate changes that will support smart city projects. The more citizens are involved in the city's development process, the better the city will serve the needs of its inhabitants. City authorities must be a driving force enabling Smart City-related activities. Without such leadership, it would be almost impossible to transform 'ordinary' cities in Slovakia into smart cities. Cities, as public and transparent players, are becoming natural open and innovative platforms. It is important that they perceive and support emerging innovative ecosystems.

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Urban geographical patterns of the relationship between mobile communication, social networks and economic development – the case of Hungary

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Abstract

In the post-industrial age, the transformation of urban networks and urban regions was fundamentally influenced by the rapid spread of infocommunication technologies (ICT) and the Internet. People share information in their daily lives with the help of various ICT devices and ultimately generate georeferenced data that could obtain important information about people's use of space, spatial movement and social connections. The main aim of the study is to explore the urban geographical and spatial impacts of ICT and social media networks in Hungarian cities. We focus on drawing territorial and settlement hierarchical patterns and clusters based on the mobile communication and online social network relationship data of Hungarian cities. The paper highlights the relationship between the intensity of mobile communication and the density and expansion of intercity social relations and the settlements' level of economic development, respectively. The methodology is based on mobile phone call detail record (CDR) analysis and intercity network analysis of social media activities. Our findings suggest that different communication networks follow divergent spatial patterns in Hungary. The traditional East–West dichotomy of the Hungarian spatial divide is still reflected in mobile communication, but intercity clusters based on social media activities are usually aligned to the borders of administrative structures. In several cases, we were able to identify strong intercity links between settlements with a similar level of economic development of the mesolevel spatial structure that traverses over different counties and regional borders. Results on social and demographic issues suggest that 'generation Z' could play a key role in dampening the social and economic tensions created by the digital divide in the long run. Using a multidimensional explanatory model, we could demonstrate the growing interconnectedness between digital networks and economic development.

Keywords: ICT, mobile communication, cell data, 'Apple index', social media, intercity networks

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Introduction

Knowledge-intensive industries and especially the emergence and development of information and communication technologies (ICT) opened a new chapter in urban development and is expected to be a sector that will determine economic development in the coming decades. In the post-industrial age, the transformation of urban networks and urban regions was fundamentally influenced by the rapid spread of ICT. Urbanization and ICT have not only changed the physical environment of cities, but they have also influenced changes in the social and economic environment (Portugali, J. *et al.* 2012). The restructuring of urban space has been strongly influenced by ICT. It has played an important role in all areas of human life and has also significantly reshaped people's be-

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haviour (Alias, N.A. 2013; Wiig, A. 2014). This is because people share information in their daily lives with the help of various info-communication technologies (mobile phones, smartphones, tablets, etc.) and ultimately generate knowledge in a bottom-up way. If this shared information is georeferenced, we can also obtain important information about people's use of space, spatial movement and social connections (Ciuccarelli, P. *et al.* 2014).

Sassen, S. (2001) pointed out that ICT transforms the spatial organization of society and economy, as well as consumption patterns. In recent years, however, several studies have highlighted the contradictory effects of ICT on urban development and it is still unclear how ICT affects the transformation of urban space (Audirac, I. 2005), as telecommunication technologies are changing very rapidly (Graham, S. and Marvin, S. 2002) or we are not even able to recognize the spatial effects of ICT (Firmino, R.J. *et al.* 2006). One of the questions to be answered today is whether telecommunications, the intensity of connections are better supported by the close physical connection of people and companies or whether proximity and geographical location are losing their relevance because of virtual connections due to modern ICT systems. This area of discussion could gain useful insights due to the COVID-19 pandemic that fundamentally (and prospectively not just temporarily) changed how people interact, work and move.

Many believe that ICT will fundamentally change and undermine the importance of geography and distance in urban development and a potential impact of ICT will be that people will be scattered in space and the role of cities as central places will diminish (Iammarino, S. and McCann, P. 2013). According to Cairncross, F. (2001), space and distance will play a smaller and smaller role in the future, and Gillespie, A. and Williams, H. (1988) make the point that ICT resolves geographical (territorial) differences. In contrast, some experts believe that the effects of the Internet and cyberspace on the space-time relationship will persist, so that geographical space, including spatial location and distance, will continue to play a key role in urban development (Jakobi, Á. 2013; Lengyel, B. *et al.* 2015).

Tranos, E. (2013) draws attention to the fact that the Internet and telecommunications continue to be primarily urban phenomena. Material and digital spaces are becoming more and more intertwined, building and working together. The economic performance continues to depend on stationary, material spaces, which are increasingly permeated by the Internet and the cyber network (Graham, S. 1998). Thus, the Internet and ICT ultimately increase the importance of geography and distance (Tranos, E. and Nijkamp, P. 2013). The correlation between the use of ICT and the Internet and the city is not negative, and virtual and physical contact do not replace but rather complement each other.

The main aim of the study is to explore the urban geographical and spatial impacts of ICT and social media networks through the investigation of mobile phone cell data (call detail records CDR, big data analysis) and the intercity network linkages of an online social network.

Based on these two types of data we aim to answer the following research questions:

– What territorial and settlement hierarchical patterns and clusters can be drawn based on the mobile communication and online social network relationship data of Hungarian cities?
– Are macro-level processes of mobile communication reflected in the demographic and spatial characteristics of mobile use?
– Is there any relationship between the intensity of mobile communication and the density and expansion of intercity social relations and the settlements' level of economic development?
– What is the role and weight of different digital networks in shaping territorial patterns?

The main added value of the research is that based on a novel approach and innova-

tive methodology using cell phone data and social media network analyses simultaneously, new scientific results are provided on the changing spatial structure of Hungary. This allows us to get insights into differences between traditional territorial structures and the latent digital and virtual spatial patterns.

Theoretical background

Digital divide in a digitalising world

Socio-economic disparities in Europe have a profound impact on internet use, with the result that EU countries are increasingly faced with growing digital inequalities (Stiakakis, E. *et al.* 2010). The concept of the digital divide emerged in the mid-1990s (Long-Scott, A. 1995) and became a focus of research in the second half of the 2000s. By the time research had drawn attention to the fact that Internet access and the development of the ICT sector could fundamentally increase social and territorial inequalities (Rallet, A. and Rochelandet, F. 2007). In the 2010s, a growing body of research testified that ICT undoubtedly contributes to economic development (Pepper, R. and Garrity, J. 2015). Therefore, there is no doubt that ICT and digital technologies have a positive impact on economic development, but this development is highly uneven across countries (Richmond, K. and Triplett, R.E. 2017). This process has been highlighted by several international reports in recent years as well (The Global Information Technology Report 2015; World Development Report 2016).

The World Bank's Digital Dividends (2016) report makes several key findings that are closely related to the topic of our study. On the one hand, it states that ICT and the Internet are fundamental contributors to economic growth and social inclusion, but on the other hand, we cannot ignore the fact that the digital divide can be as large as the gap between countries' economic development While 80 per cent of the world's population has access to a mobile phone, internet access is only 40 per cent. Of course, there is a significant gap in mobile and internet usage between developing and developed countries. Digital divide is predominantly increased by accessibility to the internet in developing countries and skills in the developed world and the European Union. There are also significant gender and age differences in the use of digital technologies: men and young people use them to a greater extent.

Cities as hubs of the digital space

An examination of the use of mobile communication devices in cities provides an excellent opportunity to explore the quality and characteristics of technology and communication. In urban space, the population moves between a relatively small number of locations, usually along well-defined trajectories. Csáji, B.C. *et al.* (2012) concluded that now people spend most of their time in a few locations and Song, C. *et al.* (2010) observed a 93 per cent potential predictability in user mobility. Due to urbanization, the proportion of the urban population is constantly increasing, so the population is increasingly tied to the urban space, and their daily life and mobility are increasingly taking place in the urban space. Mobile communication devices play a decisive role in communication and by collecting and examining the data generated during their use, we can essentially gain insight into the operation of the city. The easiest way to research mobile usage is to collect and analyze event-driven mobile phone network data (event means voice, SMS or data messages).

Most telephone networks generate call detail record (CDR) that are data records produced by a telephone exchange documenting the details of a phone call or SMS passed through the device. CDR data is extremely suitable to track the whole population for a long time and with relatively high spatial accuracy (Calabrese, F. *et al.* 2011a, b; Deville, P. *et al.* 2014). By implication, the more intense the mobile communication, the larger

the amount of CDR data generated, and the transmission of data requires an increasingly advanced technological background and mobile communication network. The capacity of the installed infrastructure varies dramatically across different cities and regions, thus, affecting the aggregated opportunities in these areas to participate and enjoy the benefits of the digital economy (Tranos, E. *et al.* 2013).

According to Raschke, M. *et al.* (2014) there is a close correlation between the construction of the mobile communication network (i.e. digital accessibility) and the position of cities in the settlement hierarchy. However, the digital accessibility pattern reveals an alternative urban hierarchy incorporating the cost and opportunities for virtual interaction. This new hierarchy, while still employing physical distance as a proxy for the cost and value of virtual interactions, results in European geography, where the core remains similar to the one that is revealed by more traditional accessibility measures. Research has moved to the direction of how to redraw the previous settlement hierarchy based on opportunities of mobile communications and virtual interactions. In many cases, new settlements appear as dominant hubs within the socio-economic space.

Technological development, communication and the use of mobile communication devices are predominantly concentrated in the urban areas, therefore cities can be interpreted as independent communication hubs in the digital space. We hypothesize that the communication (event and data traffic) measured in each city is closely related to the economic role, competitiveness, and productivity of the local economy.

Another source of information that can be utilized to capture the dynamics of social relations is online social network data. We suggest that it can be used as a proxy for real life social ties (Bailey, M. *et al.* 2018; Norbutas, L. and Corten, R. 2018). While family and close friendship ties constitute bonding social capital (relations) that reflects connections characterised by high levels of similarity not just in terms of demographic characteristics, values and attitudes but available information resources (Granovetter, M. 1985; McPherson, M. *et al.* 2001). On the contrary, bridging social capital describes connections that link different social groups and therefore are essential to the spread of information, ideas and resources. Cities can also be described by aggregate network characteristics of their individuals both in terms of intercity (Pan, W. *et al.* 2013) and intracity connections (Tóth, G. *et al.* 2021).

Digital networks and the socio-economic development

Early big data and network research on mobile use began in the second half of the 2000s. Dominant research institutions in this field were the Barabási's 'Center for Complex Network Research', Ratti's team of the 'MIT SENSEable City Lab' and Ahas's 'Mobility Lab 13' of the University of Tartu. Thanks to the pioneering work of the three organizations, the number and scope of research expanded significantly in the early 2010s and nowadays three distinct scopes of research related to mobile use have emerged:

1. Research on the social environment and demographic characteristics of the local population (e.g. Gonzalez, M. *et al.* 2008; Eagle, N. *et al.* 2009; Song, C. *et al.* 2010; Hernandez, M. *et al.* 2017);

2. Research related to the geographical and urban space (e.g. Ahas, R. *et al.* 2006; Becker, R.A. *et al.* 2011; EC 2014; Järv, O. *et al.* 2014);

3. Technology and network-oriented research (e.g. Onnela, J.-P. *et al.* 2007; Lambiotte, R. *et al.* 2008; Wang, P. *et al.* 2009; Calabrese, F. *et al.* 2011a, b).

Mobile phones and similarly innocuous devices opened the way to social network analyses and research on the geography of social networks (Blondel, V.D. *et al.* 2010, 2015; More, J. and Lingam, C. 2013; Schläpfer, M. *et al.* 2014). Since the mid-1990s, more and more research demonstrated that ICT is an important source of productivity.

The first studies to reveal the links between mobile use and socio-economic development appeared in the late 2000s. Eagle, N. *et al.* (2010) in a study using data from the UK suggested that the social and geographical diversity of contacts correlates positively with the socio-economic characteristics of the neighbourhood, thus, there is a relationship between the structure of a user's social network and the environment in which they live. Mao, H. *et al.* (2013) investigated the relationship between the characteristics of mobile phone network and the socio-economic status of a developing region in the Ivory Coast. They observed that high mobile communication activity seems to correspond well to regions that are important for the national economy. Smith-Clarke, C. *et al.* (2014) found that poverty levels are also linked to deviations from the expected flow of communications: if the volume of communication is significantly lower than expected from and to a certain area, then higher poverty levels are to be expected. Frias-Martinez, V. *et al.* (2013) observed that socio-economic levels follow a pattern which is basically predictable by mobile phone data. Norbutas, L. and Corten, R. (2018) analyzed network structure and economic prosperity in Dutch municipalities. They recognized that geographically long bridges are linked to economic prosperity at community level, and high network density and fragmentation are associated with lower economic prosperity. Thus, over the past decade, countless research findings have shown that CDR together with online social network data are a suitable way to demonstrate the economic performance of cities.

Methodological background

Analysis of urban mobile use based on cell data

In recent years, several summary studies on the structure and operation of mobile networks have been published, which provide a very good overview of the technological background of mobile communication systems and cell data processing (Calabrese, F. *et al.* 2014; He, Y. *et al.* 2016; Gregersen, F.A. and Lunke, E.B. 2018; Qin, S. *et al.* 2019). Therefore, in the methodological part, we do not present the technological background of mobile network systems and only introduce the methodology of our specific research.

For the research, we used the mobile cell data of Telekom Hungary's network (hereinafter Telekom). The spatial projections of mobile cells are polygons, which denote the area served by each tower. To determine the position and extent of the polygons, Telekom uses a 127 x 127 m raster network that fully covers the territory of the country. The basic unit of a polygon is, thus, the raster, for which, however, we have only estimated information. In the network of the service provider, more than 24 million rasters, and 40,000 polygons cover the territory of Hungary. In this raster network, we can localize nearly 220 million events on an average day.

Cell data provided by Telekom Hungary records the coverage area within which the subscriber is likely to be during the active use of a SIM card. The system records the minute-based time of the activity indicating the start of the activity (i.e. the time of starting/receiving a voice call, the time of sending/receiving an SMS and the start of Internet use). Besides location data, the database contains information on the country of origin, device type, age, gender, zip code and company type. The database of the service provider was supplemented with Corine Land Cover data updated in 2012 and information on the device used.

The most crucial methodological question was how to assign polygons to the examined settlements. This is because polygons can cover several settlements, rasters can appear inside or outside the city, even covering water surfaces. The most expedient solution was to divide cell data proportionally between the settlements and the areas of different character. So, if 70 out of the 100 rasters of a polygon is covering territorial unit A and 30 territorial unit B, then the equipment (SIM

card subscriber) using the tower was classified 0.7 parts to unit A, and 0.3 parts to unit B. The sum of the fractional values shows more accurately the number of Telekom subscribers in a given city. We also weighted the cell data according to the character of the raster, as in the city, mobile use is much more likely to be related to residential areas or green spaces than to agricultural areas or even water surfaces. Depending on the type of rasters, the following weighting was applied (in per cent):

– 100: Residential areas, parks, cemeteries, green areas, sports courts, airports etc.
– 50: Industrial areas, roads, railways, ports etc.
– 20: Agricultural areas, forests, water surfaces etc.

During the research, we collected data from 345 Hungarian cities and Budapest. The data was collected for 7 days between September 2018 and June 2019 including both typical weekdays and weekend days. All indicators used in the analysis are based on the average values calculated for these days.

The original dataset included several metrics for the content and intensity for mobile communication, such as frequencies for incoming and outgoing voice calls and SMSs; number of online events that required transfer of data; and number of devices that were located in the cell coverage area linked to the particular settlement. In the analysis we used per capita ratio of events and events per equipment. We also made some experiments with a special index that shows the ratio of Apple devices compared to all devices in the total number of events. Since devices manufactured by Apple are generally more expensive than competing brands, we hypothesize that the index might positively correlate with income at settlement level *(Figure 1).*

Online social network data

Besides CDR data we also used information on social relations derived from an online social network. The iWiW (International Who Is Who) was launched in 2002 and shortly became the most widely used online social network in Hungary. At its peak around 2010, it was one of the most visited national websites reaching most internet users of the country. In February 2013, the entire dataset of iWiW with information on self-chosen location (at town level) and connection data (establishment of friendship ties) was made available for us for scientific research purposes. Use of the service was limited to those aged over 14, so theoretically the maximum number of potential users was 8,2 million people in Hungary. The total number of users who chose a Hungarian settlement as their home location reached 2.8 million by early 2013 (another 600,000 users were outside Hungary). This implies that about 33 per cent of Hungarians older than 14 years were part of the network. Considering the level of internet users measured by nationally representative surveys (76%) in 2013, close to 50 per cent of the adult online population were also iWiW users.

In our analysis, social connections represented online are used as a proxy of real-life social connections. This approach is certainly a simplification of the complex social reality, but we argue that despite our data is imperfect and has certain limitations (i.e. we do not know about the nature of social connections, their strength, frequency of communication, etc.), until now it is still the best available source, and there is no such systematic bias in the data that would question the validity of the analysis. Since our analysis if focusing only on cities (345 settlements excluding Budapest) in Hungary, the representativity of the data is better than using the full dataset that includes more than 2,000 additional villages with generally lower user rates. The average iWiW user rate varied between 23 and 36 per cent across different city size categories. The use of online social networks (similar to the general use of technology) is potentially influenced by the level of economic development, therefore introducing some bias to the analysis. (Tóth, G. *et. al.* 2021). However, the use of weighted network metrics eliminates the problem.

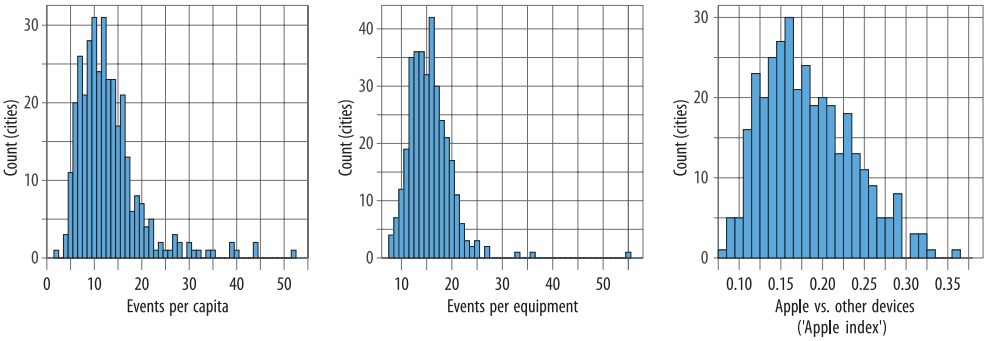

Fig. 1. Distribution of mobile communication metrics

Network measure for identifying the relative strength of city-to-city connections

Based on the methods described by Lengyel, B. *et al.* (2015), Jakobi, Á. (2017), and Tóth, G. *et al*. (2021) we calculated three network indicators for the subset of 345 cities in Hungary.

- The overall embeddedness of a given city was measured by the log-likelihood ratios of observed and randomly expected settlement-to-settlement tie weights. This indicator controls for the bias derived from the different size (and therefore different number of iWiW users) of cities. Smaller values indicate generally weaker connections to other cities, while larger values imply a higher level of embeddedness to the social network of cities. *Figure 2* shows the slightly right skewed distribution of average weights in cities peaking around -1.5.
- Average relative distance rates refer to the physical distance of connections a city has with other cities in the country. Since the absolute distance of connections largely depends on central or peripheral geo-position of a settlement (Jakobi, Á. 2017, 206) we used relative distance rates that account for the comparison of the observed and expected distance averages.
- While the first two measured were intended to capture the intercity network characteristics, social network fragmentation was calculated for each intracity networks in our dataset. Based on the Louvain algorithm the density of edges within groups was compared to the density across groups, and then scaled by a theoretical maximum value when all edges were within the communities. Intracity networks with high fragmentation have dense connections between the nodes within communities but sparse connections between nodes in different communities.

Results

Spatial and demographic characteristics of mobile use

The results of our big data analysis based on mobile phone use and related to the spatial patterns and networks of digitalization reflect previous geographical results obtained using traditional research methods. *Figure 3* shows the traditionally underdeveloped areas, which proves that the results of big data investigations can be used in spatial analysis and urban mobile use investigations provide relevant information on spatial processes.
Based on the event per capita and the event per equipment indicator and related statistics, the following groups of settlements can be identified as defining digital nodes in the Hungarian city network system:

1. Budapest and Budapest Metropolitan Region. The city and districts of the downtown

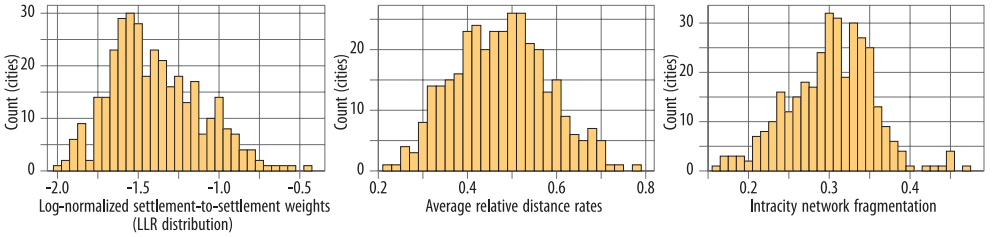

Fig. 2. Distribution of network metrics

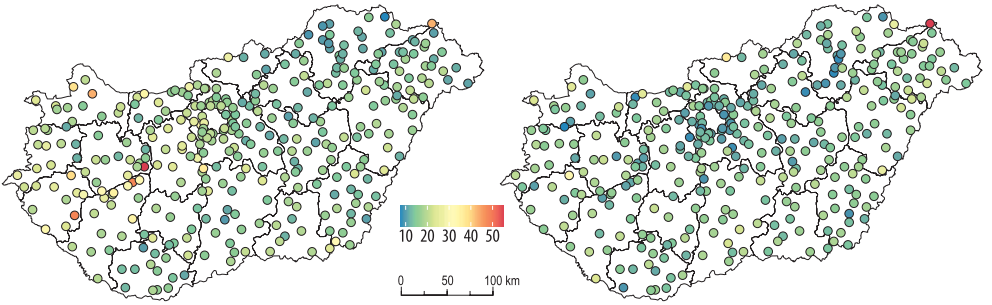

Fig. 3. Event per capita (left) and event per equipment (right) indicator in Hungarian cities.

(e.g. districts I., V. and VI.) as well as the cities of the western sector of the agglomeration zone (e.g. Törökbálint, Budaörs);

2. Cities along major transport axes and motorways (e.g. Komárom and Lébény along the Budapest–Hegyeshalom axis of M1 motorway leading to the West, Rácalmás – the headquarter of Hankook Tires in Hungary – along the M6 motorway leading to the South);

3. Cities and spa towns with significant tourist potential (e.g. Zamárdi and Zalakaros near Lake Balaton, and Visegrád near Budapest);

4. Cities located near significant border crossings (e.g. Záhony, at the border to the Ukraine).

The "digital desert" of the city network consists of the following groups of settlements:

1. Cities located on the periphery from a geographical settlement point of view (e.g. Sajószentpéter in Borsod-Abaúj Zemplén county, and Salgótarján, the county seat of Nógrád county, both counties located in Northern Hungary);

2. Settlements located in so-called inner peripheries from a socio-economic point of view (e.g. Rákóczifalva in the Great Plain, Sásd in Southern Transdanubia, and Répcelak in Western Transdanubia).

We hypothesized that mobile phone use reflects Hungary's traditional economic pattern. Research over the past decades has shown that, on the one hand, the Hungarian economy is characterised by a significant West–East divide with higher levels of development in the central and western part of the country (e.g. Budapest and Western Transdanubia), and on the other hand, the most underdeveloped areas of the country are located in the south-west and north-east (e.g. Baranya, Borsod-Abaúj-Zemplén and Szabolcs-Szatmár-Bereg counties) (Nemes Nagy, J. and Tagai, G. 2011; Dusek, T. *et al.* 2014; Győri, R. and Mikle, G. 2017).

To prove the West–East dichotomy in digitalization and mobile use, we calculated the correlation between cell data and the coordi-

nates of the GPS geodetic reference system of the WGS84 (World Geodetic System 1984). This grid system is used to determine the geographical (spatial) position. During the investigations, we examined the correlation between the values of data traffic per event indicator measured in cities and the longitude coordinates of cities given in the WGS84 system. The reference settlement was Szentgotthárd as the most Western city in Hungary.

In the WGS84 system, the West–East slope was clearly detectable in the spatial change in mobile cell data. The farther to the East the city is from Szentgotthárd, the lower the data traffic/event index. The correlation shows a medium-strong co-movement with reverse sign in both small towns and large cities. We also calculated the correlation with Budapest as the reference settlement as well. Results indicate that mobile use decreased with distance from the capital city, the correlation shows a moderate co-movement with reverse sign. The core–periphery relation shows a lower correlation than the West–East dichotomy (*Table 1*).

We also hypothesized that the spatial patterns drawn in urban mobile communications are also reflected in the demographic and spatial characteristics of mobile use. We examined the demographic and territorial processes underlying mobile communication through the use of mobile devices by different generations (i.e. generations X, Y and Z). The proportion of smartphones among mobile users is a simple yet excellent indicator that is suitable for exploring the differences in mobile use between generations and its spatial pattern. Information on the age of the subscribers was provided by Telekom for 10-year cohorts, so generations could be defined as follows: generation X (41–60 years old), generation Y (21–40 years old), generation Z (11–20 years old). Due to the division by cohorts, the identification of generations slightly differs from the official, scientific age classification of these generations.

Nationwide, the proportion of smartphone users is 85.5 per cent, which is for information only, as for many users, the cell information does not include the type of mobile device used. The technological proficiency of generation Z is well reflected in the type of mobile phones and communication devices used. Members of generation Z are virtually born into the use of digital technologies and are often called digital natives (Prensky, M. 2001) who are accustomed to the rapid flow of information and the rapid reception of information. It is no coincidence that the proportion of smartphone users is higher in all city categories compared to other generations *(Table 2).* In this table only those subscribers are counted whose mobile device could be identified.

The share of smartphones in all settlement categories shows significant differences between generations. We can state that the use of smartphones, which actually represents a higher level of technology and require more proficiency, decreases with age. However, this trend will clearly fade out in the future, as with the ageing of generation Z, technological proficiency will reach an ever higher level in society. On the other hand, we have

Table 1. Correlation between events per capita, events per equipment and distances from Szentgotthárd and Budapest

City size by population	Events per capita		Events per equipment	
	Distance from		Distance from	
	Szentgotthárd*	Budapest	Szentgotthárd*	Budapest
over 100,000	-0.263	-0.397	-0.560	-0.533
50,001–100,000	-0.597	0.562	-0.501	0.639***
20,001–50,000	-0.339	-0.148	-0.183	0.476***
5,001–20,000	-0.379***	-0.054	0.000	0.383
under 5,000	-0.375***	-0.224**	0.191**	0.230**

*The most Western city in Hungary, **p < 0.05, ***p < 0.01.

Table 2. Ratio of smartphone users in the generations, %

City size by population	Generation				Total
	Z	Y	X	over 60	
over 100,000	95.9	93.8	88.1	65.6	86.7
50,001–100,000	96.6	94.0	88.3	65.4	86.7
20,001–50,000	96.0	93.4	87.5	64.5	85.9
5,001–20,000	95.8	93.2	87.3	65.1	86.5
under 5,000	94.9	93.2	87.7	67.0	87.2
Total	*95.6*	*93.2*	*87.5*	*65.6*	–

to emphasize that no significant differences can be detected within the same generation at the different settlement category levels. Comparing our results with those of *Table 2*, we can conclude that higher position in the settlement hierarchy brings along more active mobile phone use in each generation.

Looking at the spatial pattern of the use of communication devices in cities, we can state that the spatial characteristics of mobile phone users of generation Z in Hungarian cities significantly differ from those of generation X and Y. For generation Z, no characteristic spatial pattern is recognizable, which means no significant difference can be detected in the geographical pattern of mobile use (*Figure 4).* This process is particularly striking in the case of smaller cities. Thus, generation Z can successfully contribute to reducing the negative effects of the digital divide.

Another noteworthy result comes from the use of the 'Apple index' that was calculated from the mobile communication dataset *(Figure 5).* The share of Apple device users (compared to other brands) ranges from 7.98 per cent (in Mezőkovácsháza, average income per capita: 1.21 million HUF) to 35.91 per cent (in Budaörs, average income per capita: 1.92 million HUF) with a mean value of 18.19 per cent. *Figure 5* shows that the 'Apple index' is a relatively reliable predictor ($R^2 = 0.69$, $p < 0.001$) of income per capita at settlement level. (There might be some biases that we could not control for: mobile events might not only be linked to local population but also to devices that are owned by people who only temporarily work or just pass through the settlement.) Nevertheless, this indicator is a good example of such big data – CDR sources that could complement and/or validate official statistics (Blumenstock, J. *et al.* 2015).

In the tail end of the coordinate system, where the low share of Apple devices is coupled with low per capita income, we find mainly small towns with less than 5,000 inhabitants located in the periphery and inner

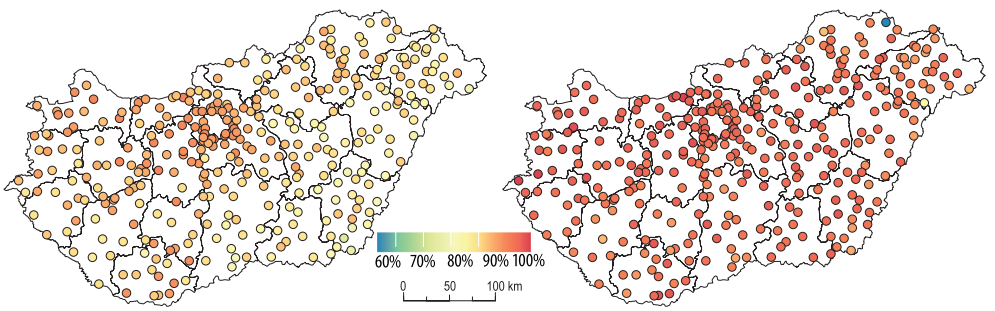

Fig. 4. Ratio of smartphone users in the generations X (left) and Z (right) in Hungarian cities, in per cent

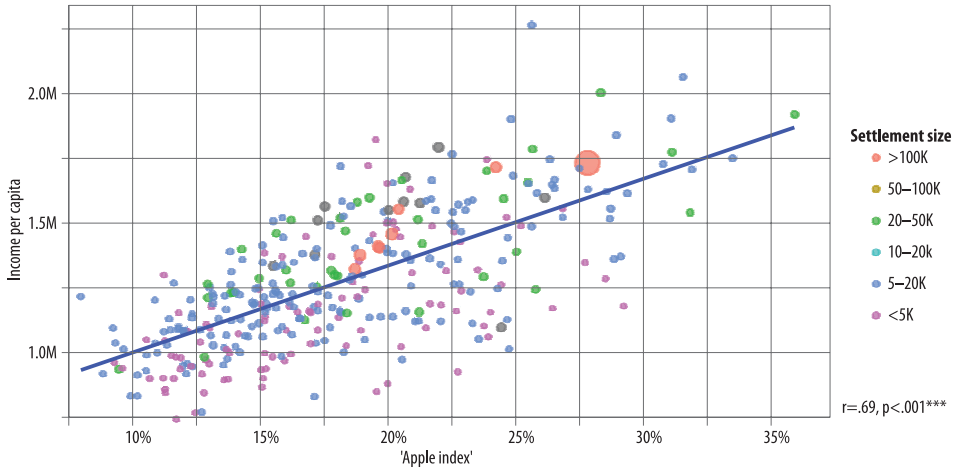

Fig. 5. Relationship between average income per capita and the share of Apple devices among users, in per cent

periphery of the country (where the average ratio of Apple devices is 17.2%). Moving up the settlement hierarchy, as the size of cities increases, the overall position of each category of cities in the model becomes more favourable and the share of Apple devices increases (with average for cities with a population of more than 100,000 inhabitants of 21.2%). Large cities (regional centres and county seats) therefore have an 'Apple index' slightly above the national average. In the upper section of the coordinate system we find the wealthiest cities located on the Buda side of the Budapest metropolitan region (Budaörs, Törökbálint, Budakeszi, Biatorbágy). Our results, thus, show a strong correlation between the 'Apple index', per capita income and position in the hierarchy of municipalities. The position of the towns alongside the Lake Balaton and spa towns with significant tourism is surprising: an above-average 'Apple index' is associated with lower per capita income, supposing that these cities attract many people of the middle class in wealthier cities of the country as visitors and tourists. The 'Apple index' is the lowest in Békés county (12.6%), which is experiencing significant social and economic difficulties, and highest in Pest county (24.3%), which actually includes the Budapest agglomeration.

Spatial patterns and clusters of intercity social networks

Using the pairwise LLR weights and filtering to city-to-city connections with LLR weights larger than 2, we were able to identify several (n = 13) densely connected groups of cities in Hungary. The clustering was based on the Louvain method (Blondel, V.D. *et al.* 2008). Certainly, the results are in line with the findings of the earlier study of Lengyel, B. *et. al.* (2015) using data for all available settlements in Hungary.

Based on the map of *Figure 6* and *7*, some general observations could be made. Most importantly, the borders of the clusters tend to resemble the administrative county and planning-statistical region borders, however, in some cases they overlap them. The map of the clusters clearly demonstrates that based on their social connections, cities in the Budapest agglomeration does not constitute an integral spatial structure. Rather it disparts into independent northern, western, and eastern sectors that are only loosely connected to each other.

There are two remarkable natural barriers that also limit the formation of social connections. Ties overarching the northern and

Fig. 6. Statistical-planning units in Hungary – Counties and regions

southern shore of Lake Balaton, and also ties between cities lying on the left and right sides of the Danube are clearly weaker.

Additionally, the administrative and intercity social networks of the regions of Western and Central Transdanubia in the northwestern part of the country does not overlap. The less developed Zala county in Western Transdanubia is rather connected to the least developed Veszprém county of the Central Transdanubia region forming Cluster 2. Cluster 13 mostly covers the western agglomeration zone of Budapest. The administrative regional and county boundaries between regions of Northern Hungary and Northern Great Plain are increasingly blurred by the spatial pattern of intercity social network relations and are aligned with a west-east developmental slope (Clusters 7–10). A narrow buffer zone (Clusters 8 and 10) separates the larger western half of the area (Cluster 7) and the smaller eastern half (Cluster 9). In the western and north-western as well as in the northern and north-eastern part of the country, digital networks could lead to a major change in the spatial pattern in the long term.

In terms of digital network interconnections, the Southern Great Plain and South Transdanubia regions appear as well-defined autonomous areas. However, there are very few intercity network connections between the western half (Cluster 12 – Bács-Kiskun county, and Cluster 3 – Somogy county) and the eastern half (Cluster 11 – Csongrád-Csanád and Békés counties, and Cluster 4 – Baranya and Tolna counties) of the two regions.

Budapest and Pest county (autonomous administrative regions since 2018) cannot be considered as separate territorial units from a digital network perspective. The circular agglomeration of Budapest does not constitute a unified cluster, instead it is split into northern, eastern, southern and western sectors.

Using data for 2018 we compared individual cities and city clusters with their average level of income per capita. The cities that build up each cluster have different positions in their sub-networks. In absolute terms,

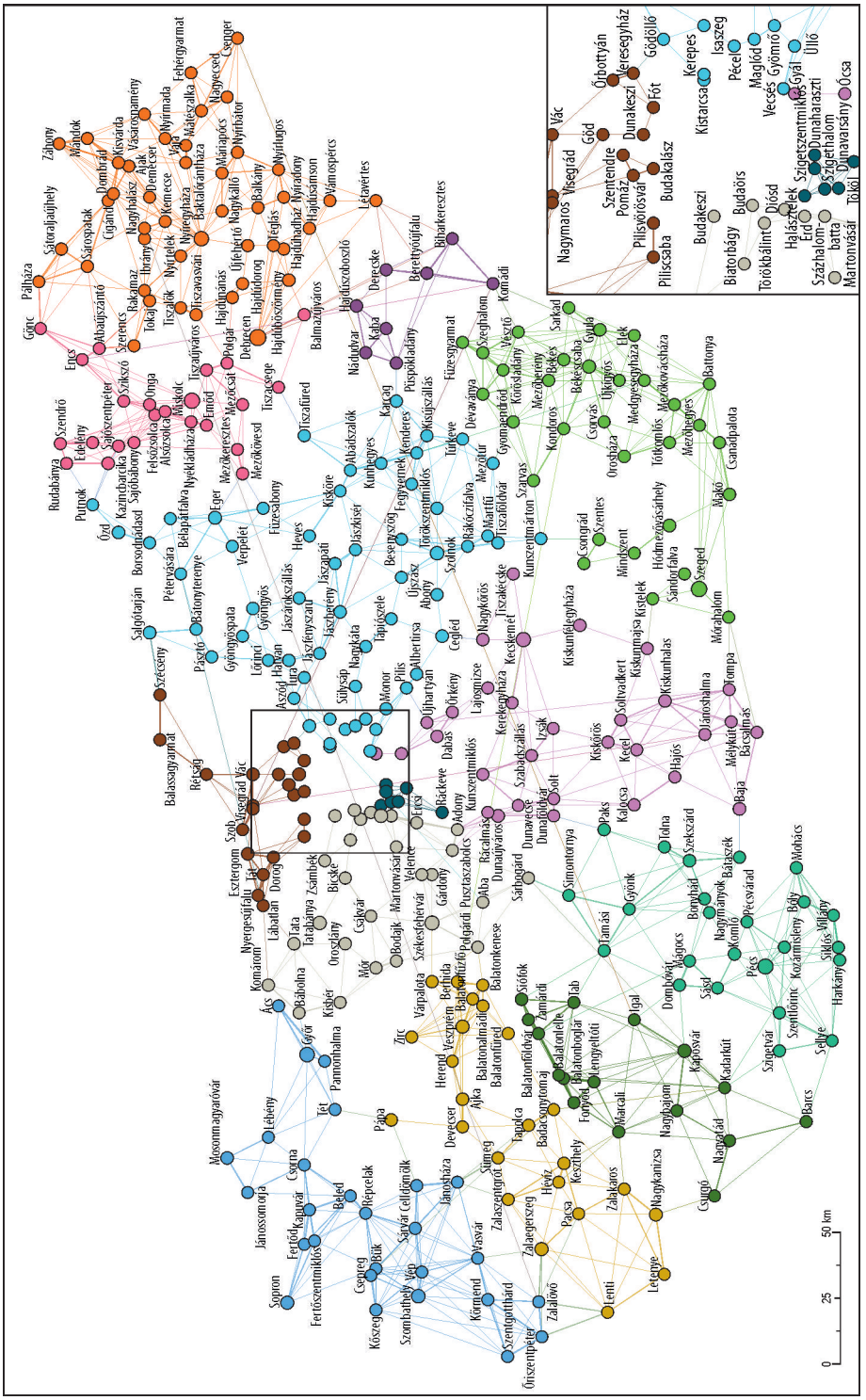

Fig. 7. Intercity clusters identified by the strongest ties across cities.

large cities (e.g. county seats) are responsible for the majority of links in the network. However, when controlling for their size, a different pattern emerges, and in many cases the strongest relative connections are to be found between smaller cities.

The presence of strong or weak external ties could also be linked to the economic development of cities. Left part of *Figure 8* shows a significant linear relationship between city-to-city weighted connections and income per capita ($r[345] = 0.60$, $p < 0.001$). Similar pattern could be observed for the 13 intercity network clusters. The three clusters (No. 5, 6 and 13) that occupy the central region of Hungary have the highest level of income with larger LLR weights indicating stronger external connections. At the opposite end of the plot, we find the majority of clusters (No. 8, 9, 10, 11 and 12) that represent the eastern part of Hungary with weaker average (weighted) intercity connections that also implies low average cluster-level incomes (*Figure 8*, right). We might conclude that cities having strong and extensive connections to other cities tend to have more wealthy inhabitants. On the contrary, cities that are weakly integrated with their close neighbourhoods and have less intense connections to farther cities (we might call it city-level bridging social capital) have lower levels of income. Furthermore, these patterns seem to be valid for networks of cities (*Figure 8*, right).

Discussion – Building a multidimensional explanatory model

The overall aim of our paper is to find connections between city-level measures of online social network indicators, patterns of mobile communication and the level of income. To understand the relationship among these factors we applied a hierarchical multi-nominal regression model where the dependent variable is the city-level average income per capita. (Due to its size and other characteristics, Budapest was excluded from the analysis.) The first two models include social network and mobile communication variables separately. Their joint effect and control variables are incorporated to the remaining two models *(Table 3).*

Results of Model 1 show that intercity and intracity social network characteristics are in strong connection with the average level of income. Intracity fragmentation of networks, together with the two indicators measuring the strength of intercity connections and their average distances explain 44 per cent ($R^2 = 0.440$, $F[3,340] = 88.89$, $p < 0.01$) of the dependent variables' variance. Beta coefficients indicate that higher levels of fragmentation and stronger intercity network ties are positively correlated with the level of income, while the average relative distance of intercity ties is negatively correlated with it. Certainly, the size of the settlement might be a confounding factor that is included in the final complex model.

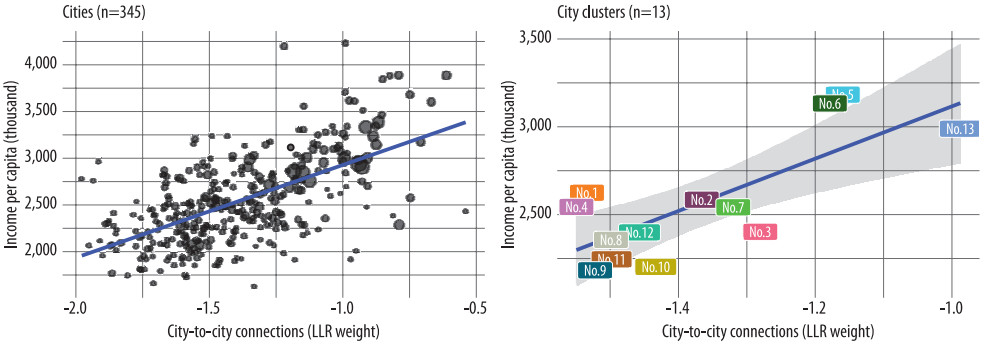

Fig. 8. Average income per capita and city-to-city connections in cities (left) and clusters (right)

Table 3. Regression results using income per capita as the criterion

Predictor	beta	beta 95% CI [LL, UL]	sr^2	sr^2 95% CI [LL, UL]	r	Fit	Difference
Model 1							
Fragmentation	0.32**	[0.24, 0.41]	0.10	[0.05, 0.15]	–	–	–
Avg LLR weight	0.59**	[0.49, 0.68]	0.25	[0.17, 0.32]	–	$R^2 = 0.440$**	–
Avg Relative Distance	-0.21**	[-0.30, -0.11]	0.03	[0.00, 0.06]	–	95% CI[0.36, 0.50]	–
Model 2							
Events per capita	-0.21**	[-0.30, -0.11]	0.03	[0.00, 0.05]	0.18**	–	–
Events per equipment	0.23**	[0.14, 0.31]	0.04	[0.01, 0.07]	-0.06	$R^2 = 0.512$**	$\Delta R^2 = 0.072$
'Apple index'	0.82**	[0.73, 0.91]	0.46	[0.39, 0.54]	0.68**	95% CI[0.44, 0.57]	95% CI[0.03, 0.11]
Model 3							
Fragmentation	0.15**	[0.07, 0.24]	0.02	[-0.00, 0.04]	0.43**	–	–
Avg LLR weight	0.25**	[0.14, 0.37]	0.03	[0.00, 0.05]	0.55**	–	–
Avg Relative Distance	-0.04	[-0.14, 0.06]	0.00	[-0.00, 0.01]	0.10	–	–
Events per capita	-0.16**	[-0.25, -0.07]	0.02	[-0.00, 0.03]	0.18**	–	–
Events per equipment	0.14**	[0.05, 0.24]	0.01	[-0.00, 0.03]	-0.06	$R^2 = 0.560$**	$\Delta R^2 = 0.048$**
'Apple index'	0.58**	[0.46, 0.70]	0.12	[0.07, 0.17]	0.68**	95% CI[0.49, 0.61]	95% CI[0.02, 0.08]
Model 4							
Fragmentation	0.16**	[0.08, 0.24]	0.02	[0.00, 0.04]	0.43**	–	–
Avg LLR weight	0.23**	[0.12, 0.34]	0.02	[0.00, 0.04]	0.55**	–	–
Avg Relative Distance	-0.13*	[-0.22, -0.03]	0.01	[-0.00, 0.02]	0.10	–	–
Events per capita	-0.14**	[-0.23, -0.05]	0.01	[-0.00, 0.02]	0.18**	–	–
Events per equipment	0.16**	[0.07, 0.25]	0.01	[-0.00, 0.03]	-0.06	–	–
'Apple index'	0.36**	[0.23, 0.49]	0.04	[0.01, 0.06]	0.68**	–	–
Population	0.12**	[0.04, 0.20]	0.01	[-0.00, 0.02]	0.28**	–	–
Distance from Budapest	-0.26**	[-0.35, -0.17]	0.04	[0.01, 0.06]	-0.58**	$R^2 = 0.618$**	$\Delta R^2 = 0.058$**
E-W distance from Szentgotthárd	-0.12**	[-0.20, -0.03]	0.01	[-0.00, 0.02]	-0.36**	95% CI[0.55, 0.66]	95% CI[0.03, 0.09]

Note: *beta* indicates the standardized regression weights; sr^2 represents the semi-partial correlation squared; *r* represents the zero-order correlation. *LL* and *UL* indicate the lower and upper limits of a confidence interval, respectively. *p < 0.05, ** p < 0.01.

Model 2 ($R^2 = 0.512$, $F[3,340] = 118.9$, $p < 0.01$) includes indicators that capture the mobile communication patterns. Events per capita and events per equipment have medium size effects while the 'Apple index' seems to be a very strong predictor of average city-level income. Events per capita has small but negative, and events per equipment has small but positive coefficients. This indicates that more devices per capita do not necessarily mean higher income, but the generally higher frequency of device use, and the presence of more Apple devices result in higher average income levels.

Model 3 ($R^2 = 0.560$, $F[6,337] = 71.4$, $p < 0.01$) is an intermediary step and it includes variables from both Model 1 and 2.

In Model 4 we introduced three control variables: population, distance from Budapest, and distance from the most Western city of the country (Szentgotthárd). The last two indicators are intended to measure the core-periphery and East–West relations of the country, therefore, we control for the most basic patterns of spatial inequalities in the country. The overall fit of this complex model 62 per cent which could be considered as quite high ($R^2 = 0.618$, $F[9,334] = 61.93$, $p < 0.01$), and basic assumptions that relate to the residuals are met. (See *Figure 9* for the distribution of studentized residuals, Q-Q plot of observed against theoretical values and a scatterplot of studentized residuals against predicted values.) The results show that both social network indicators and measures of mobile communication are significantly predicting the average city-level income in Hungary.

The results of the above model indicate that both the characteristics of the settlement-level online social networks (as proxy for 'real' social network connections) and various measures of mobile communication patterns are in strong connection to the wealth of cities in Hungary. Echoing the findings of Jackson, O.M. (2008), Kadushin, C. (2012), and Helsley, R.W. and Zenou, Y. (2014) higher level of embeddedness to the network of other cities seems to be a particularly important explanatory variable for economic development. However, not only the extension of the social network, but the intensity of communication and the type of devices used for communication also matter. The results of the model and our preliminary descriptive analysis show that the penetration of devices both spatially and socially has reached a level of saturation. The possibility of mobile communication is almost evenly accessible throughout the country. On the contrary, our results are in line with previous findings of Eagle, N. *et al.* (2010) and Mao, H. *et al.* (2013) that it is not the number of devices but the frequency of using them is that plays an important role in explaining the local level of income. In simple terms and empirically proving the common sense: sustained use of expensive devices are clear indicators of

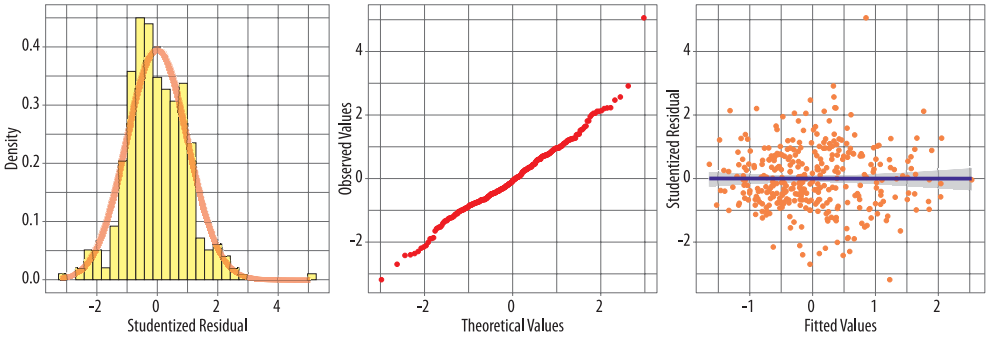

Fig. 9. Analysis of studentized residuals and fitted values of the final model (Model 4)

wealth. The interconnection of these factors also holds when controlling for the basic inherencies for spatial inequalities in Hungary.

Conclusions

Communication networks follow divergent spatial patterns in Hungary. The traditional East–West dichotomy of the Hungarian territorial system still seems to be reflected in ICT use in Hungary, however, there is growing spatial concentration that results in the weakening of the traditional West to East incline which is more and more replaced by the distance from Budapest and to a lesser extent from the regional centres. These trends can be explained by the growing importance of Budapest and its agglomeration in the Hungarian creative economy, and the metropolitan region of Budapest is the central hub for the development of the ICT sector (Egedy, T. *et al.* 2018). Our results fit with the mainstream research findings (e.g. Raschke, M. *et al.* 2014; Schläpfer, M. *et al.* 2014) that the settlement hierarchy has great impact on the diffusion of ICT and the use of mobile devices.

There are significant differences between the different generations in the type of device across all categories of the settlement hierarchy (smartphone predominance in generation Z). Within each generation, the main difference between settlement categories is in communication activity (more active mobile use in the higher levels of the settlement hierarchy and low activity in the peripheral small settlements).

Our research has further refined previous international findings of Eagle, N. *et al.* (2009), Richmond, K. and Triplett, R.E. (2017), and statements of the Digital Dividends Report (2016) in that to some extent the digital divide that exists in the spatial structure can be compensated by social conditions. Different mobile device usage patterns of 'generation Z' could dampen the social and economic tensions created by the digital divide in the long run.

The second set of analysis focusing on intercity network did not unfold East–West dichotomy: clusters are usually aligned to the borders of administrative structures. In several cases we were able to identify strong intercity links between settlements with similar level of economic development of the mesolevel spatial structure that traverse over different counties and regional borders. Our research has successfully contributed to previous research of Onnela, J.-P. *et al.* (2007) and Blondel, V.D. *et al.* (2015) on the role and characteristics of social networks.

We also suggest from the results of the network analysis that signs of disintegration can be observed in the traditional administrative spatial structure: new sub-networks of nodes and links are emerging that are independent from the trajectories of the administrative spatial divides of past and present. Our results corroborate the theory of Tranos, E. *et al.* (2013) emphasizing the emergence of new hubs in city structures in digital networks and the growing importance of second-tier cities. This process is particularly marked in the western and north-western and northern and north-eastern part of the country, respectively.

According to Tóth, G. *et al.* (2021) social network cluster borders are not only following administrative boundaries. The virtual structure of space is also affected by natural geography (e.g. Lake Balaton, the river Danube, Bükk Mountains in the north-east). These constitute strong natural barriers that also have a clear impact in the virtual space. Based on our online social network data, the emergence of intercity networks cannot be separated from the physical space.

Infocommunication technologies and virtual networks are playing a key role in the development of smart cities in the digital age. Our results suggest that economic development is predominantly connected to the level of embeddedness to intercity networks. The direction of causality is rather twofold here, so it is not the case that dense connections are creating wealth or higher level of wealth leads to more social connections. Here we see a complex interplay of historical trajectories and current

economic and social processes. ICT is actively shaping both the geographical and virtual space and therefore transforming the role of physical space and its interpretations. In the case of Hungary, it is mainly in the northern part of the country (both East and West) that digital networks are deviating more significantly from the classical administrative territorial structures and where a major transformation of digital patterns is expected in the near future.

The cluster analysis of the digital networks could support re-thinking the traditional spatial structure of Hungary, and also to outline a new, network-based spatial structure. However, it needs further fine-tuning with more research using alternative data sources.

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Acceptance of a smartphone navigation application by hospital patients and visitors: the role of gender, age, and education

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Abstract

This paper analyses the acceptance of a smartphone navigation app in a hospital among its patients/visitors. We tested the effects of socio-demographic factors (gender, age, and education) on technology acceptance and on perceived difficulties with wayfinding in the hospital complex. The empirical research is based on a survey among 928 patients/visitors of the Vítkovice Hospital in Ostrava, Czechia. We found that the acceptance of smart navigation increases with the level of education and decreases with age. No significant gender differences were observed.

Keywords: technology acceptance, hospital, gender, age, education, smartphone navigation

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Introduction

There are several reasons why wayfinding in hospitals requires systematic research. Many authors document increasing difficulties with wayfinding in large complex buildings, including hospitals (Hölscher, C. *et al*. 2006; Anagnostopoulos, G.G. *et al*. 2017). Patients and visitors of healthcare facilities may face considerable anxiety and stress resulting from navigational issues (Wolstenholme, D. *et al.* 2010; Devlin, A.S. 2014). Staff members also face difficulties in wayfinding and are often asked for advice by hospital patients and visitors, which may negatively affect their productivity (Mollerup, P. 2009). Navigational needs and strategies, spatial and wayfinding skills are associated with gender (Lawton, C.A. 2001), age (Harris, M.A. and Wolberts, T. 2014), education (Ženka, J. *et al.* 2021), culture (Davies, C. and Pederson, E. 2001), and, most importantly, mental and health (dis) abilities (Souza, R.F. and Martins, L.B. 2019). Wayfinding in a large complex building such as a hospital is also context-dependent, being affected by the specificities and history of the building, its architectural setting, urban design factors, and the connection of the place to other parts of the city.

Dealing with the increasing complexity of large buildings requires the adoption of technology-based smart solutions to complement traditional navigational issues, such as maps, plans, signs, arrows, or colour signs. Recently, one of the most progressive solutions to navigational issues has been the adoption of smartphone navigation applications for indoor positioning. The development and/or implementation of a useful smartphone navigation app should be based on a survey of navigational needs among the potential users.

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Thus, our first research question is to what extent the respondents (patients and visitors) accept smartphone navigation apps and use them for orientation in the hospital. The second research question is to what extent are the navigational preferences of hospital patients/visitors associated with socio-demographic factors: gender, age, and education. Finally, we also ask to what extent are the perceived wayfinding difficulties associated with gender, age, education, and location. Do men and women, younger and elderly people, or less educated and more educated people perceive the same hospital departments as difficult to find, or are there any significant differences? Based on these answers, we aim to provide specific recommendations for designing hospital navigation systems that will be based not only on theoretical arguments but also on the empirical identification of the navigational preferences and needs of hospital patients and visitors.

The empirical analysis in this paper draws on a case study of the Vítkovice Hospital (official name: 'Nemocnice AGEL, Ostrava-Vítkovice') in the city of Ostrava (Czechia). With an area of 4.2 ha and 11 pavilions, it is rather a small hospital. Therefore, patients and visitors are not in urgent need of a more technologically advanced navigational system, allowing them to cope with the complexity of the site (see Ženka, J. *et al.* 2021 for a more detailed description of the navigational system in the hospital). Nevertheless, our empirical research (see section 'Results') revealed that even in a hospital complex of this size, there are frequent issues with wayfinding among both patients and visitors.

We conducted 928 questionnaires with hospital patients and visitors, focusing on their perception of the current navigational system in the hospital, on the preferences of various types of navigational cues, and, most importantly, on their acceptance of a smart navigation application. While the existing literature on wayfinding in hospitals is abundant, we would like to contribute by connecting two different avenues of research:

a) Theoretical papers testing the effects of gender, age, and education on wayfinding (Lawton, C.A. 2001; Iaria, G. *et al*. 2009; Anacta, V.J.A. and Schwering, A. 2010; Silber-Varod, V. *et al.* 2019; Mendez-Lopez, M. *et al.* 2020);

b) Applied studies analysing the technological or management aspects of hospital navigation systems (Balata, J. *et al.* 2013; Calderoni, L. *et al*. 2015; Anagnostopoulos, G.G. *et al.* 2017).

In the next section, we discuss the determinants of people's willingness to use smart navigational applications, focusing on the effects of age, gender, education, and their possible interactions. The third section provides the characteristics of data sources and methods, while the fourth presents the selected results of statistical tests. In the fifth section, we compare our empirical findings with those of other authors. The sixth section concludes.

Gender, age, education, and their effects on technology acceptance

The primary dependent variable in our research is technology acceptance: the propensity of patients/visitors to use a smart navigation app in the hospital. The traditional explanation of the adoption and usage of telecommunication technologies is provided by the digital divide model (Rice, R.E. and Katz, J.E. 2003), based on the effects of gender, age, and education. The adoption of technology improves with the level of education and declines with increasing age. Younger people and people with a higher level of formal education should adopt technology faster than older people and people with a lower level of education. Older individuals tend to face greater difficulties in processing new or complex information, which affects their use of modern technologies (Custodio, R. *et al*. 1986; Morris, M.G. *et al.* 2005). This problem can be attributed to a decline in cognitive and memory skills related to the ageing process (Posner, R.A. 1997; Venkatesh, V. *et al.* 2012). These authors contend that the adoption and

use of mobile internet technology lessens with age, as older men in particular rely more on established habits than on mobile internet technology. Harwood, J. (2007) argued that different age groups have different behavioural patterns in mobile technology use.

Men are generally assumed to adopt technology faster than women, but this applies only in the early phase of the adoption of the technology. Several authors have documented small gender differences in the ability and willingness to use smart navigation technologies (Hwang, K.H. *et al*. 2016; Silber-Varod, V. *et al*. 2019; Ženka, J. *et al.* 2021). Custodio, R. *et al*. (1986) argue that less-educated users may be financially constrained in the use of modern technologies. Educated young users, on the other hand, are increasingly using e-maps and other mobile apps because they are encouraged to do so in school and when using social networks (Lapon, L. *et al.* 2020). Nevertheless, interactions between gender and education or gender and age may affect patterns of individual willingness to use technology more significantly than the isolated effects of these sociodemographic variables. To capture these associations, we discuss briefly two sophisticated theories that are useful for the explanation of individual technology acceptance.

In general terms, our point of departure is the theory of planned behaviour (TPB) (Ajzen, I. 1991). This psychological theory explains an individual intention to perform behaviour by the effects of three variables: attitude toward a behaviour, subjective norm, and perceived behavioural control (PBC). The attitude toward using technology is defined as a respondent's effective evaluation of the benefits and costs of using the technology (Morris, M.G. *et al.* 2005); in our paper it is the perceived usefulness of the smart navigation app. Subjective norm is 'the perceived social pressure to perform or not to perform the behaviour' (Ajzen, I. 1991, 188): e.g. public/marketing pressure and the recommendations of 'important people in my life' to use the smart navigation app in the hospital. PBC is related to the availability of skills, resources, opportunities, and their importance in the achievement of the outcome, defined as the 'perceived ease or difficulty of performing the behaviour' (Ajzen, I. 1991, 188). In this case, it covers financial costs, necessary knowledge to manage the smart navigation app, own control over the app, and its compatibility with other relevant software systems and applications. For our research, we employ also the unified theory of technology adoption (UTAUT) in the second version (Venkatesh, V. *et al*. 2012; – see also Venkatesh, V. *et al.* 2003 for the first version), applying the principles of TPB to explain individual intention (not) to use technology.

According to this theory, gender and age moderate the relationship between the explanatory variables (performance expectancy, effort expectancy, social influence, facilitating conditions, price value, hedonic motivation, and habit) and the intention to use a new technology (Venkatesh, V. *et al.* 2012). Gender differences in the importance of facilitating conditions (training, support) become more distinctive with age (Morris, M.G. *et al.* 2005). Older women place more emphasis on facilitating conditions and effort expectancy (ease of consumer's use of the technology) when adopting a new technology, especially in the early stages of adoption. They are more determined to use these technologies when they become aware that these technologies will make their lives easier (Hwang, K.H. *et al*. 2016). Men, on the other hand, tend to rely less on facilitation conditions and more on performance expectancy (perceived benefits associated with the use of technology) when considering the use of a new technology (Morris, M.G. *et al.* 2005). This can also be partly explained by the effect of gender roles in society, where men tend to be more task oriented (Lynnot, P.P. and McCandless, J. 2000). For users with less experience of modern technologies, the effect of age and gender on their technology acceptance will be more significant than for more experienced users.

Finally, we turn to the geographical aspects of technology acceptance in hospitals, considering the role of gender, age, and education.

To our best knowledge, no theoretical framework linking technology acceptance and spatial factors exists. The intention to use a smart navigation app should be higher in large, complex, and uniformly designed buildings. The absence or low visibility of landmarks and other navigational cues (arrows, maps, colour strips) is expected to increase technology acceptance. Women should be more sensitive to these issues for several reasons:

a) they exhibit higher levels of uncertainty and spatial anxiety than men (Lawton, C.A. 1994; Mendez-Lopez, M. *et al.* 2020);

b) women perform slightly worse in spatial orientation in the real environment than men (Coluccia, E. and Louse, G. 2004);

c) women rely on a 'route strategy' in their navigation (Lawton, C.A. 1994; Liao, H. and Dong, W. 2017), following the sequence of landmarks and left-right turns, while men prefer cardinal directions (North–South), global reference points (central square, airport, sun in the sky) and Euclidean distances (see also Lawton, C.A. *et al.* 1996, or Ženka, J. *et al*. 2021).

Therefore, men are expected to evaluate orientation in the hospital complex as a whole, while women may view some buildings/parts of the complex as very easy and the others as very difficult to find. They should be more polarized in their evaluations of particular buildings and their perceived wayfinding difficulties should be more spatially concentrated at the level of buildings in the hospital complex. Correspondingly, the same differences are expected between younger and older people and between people with elementary, secondary, and tertiary education. With increasing age, the spatial abilities of elderly people deteriorate (Newman, M.C. and Kaszniak, A.W. 2000; Devlin, A.S. 2014), and elderly people rely more on the route strategy than younger people (Rodgers, M.K. *et al.* 2012). Less educated people show lower orientation scores (Ulrich, S. *et al.* 2019) and are likely to follow a route strategy, while empirical evidence for the latter is missing. To sum up, we expect that the acceptance of smart navigation apps will differ among particular hospital pavilions and departments, depending on the perceived difficulties of finding these places. This relationship will be stronger among women and among elderly or less educated people. In the next section we describe the data and methods used to test these relationships.

Data and methods

To collect data from our respondents (patients and visitors of the hospital), we used structured questionnaires in the paper form. Respondents were asked to evaluate the hospital navigation system and assess their acceptance of a smartphone application for navigation in the Vítkovice Hospital. However, smartphone applications were not highlighted in the questionnaire, as we did not want to influence the decisions of the respondents. Focus groups, including doctors, nurses, and other medical and technical staff, were employed to improve the design of the survey (based on the approach of Brown, M. *et al.* 2016).

In the first step, we piloted the survey among 100 respondents to check the adequacy, relevance, and comprehensibility of the questions. Based on the results, we adapted or reformulated several questions to improve their comprehensibility. Next, 4,000 questionnaires were distributed to the selected departments of the Vítkovice Hospital (according to the mean weakly number of patients) between 26th June and 3rd July 2019 (a working week). The response rate was 23.2 per cent, as we collected 928 filled questionnaires. Respondents answered 13 questions about their previous experience with wayfinding in the hospital/department, their willingness to use the smartphone application, or traditional navigational cues. In this paper, we analyse six selected questions (*Table 1*). Some questions were not answered by all respondents or were answered incorrectly. Therefore, the number of valid responses (N) among the various questions varied slightly.

Table 1. Variables employed in the statistical analysis

Variable name	Type	Scale	Description
Wayfinding difficulties	dependent	ordinal	Is it easy to find this department for the new comers? 1 = easy; 2 = some difficulties; 3 = difficult.
SmartApp acceptance		binary	Would you use a smartphone for navigation in the hospital? 1 = yes; 2 = no.
Smartphone ownership	descriptive		Do you have a smartphone? 1 = yes; 0 = no.
Location	explanatory	nominal	Hospital pavilion, where the respondent filled the questionnaire and evaluated the difficulties with finding a way to the pavilion.
Gender		binary	0 = male; 1 = female
Age		ordinal	1 = 0–20; 2 = 21–40; 3 = 41–60; 4 = more than 60 years
Education			1 = no or elementary; 2 = secondary; 3 = tertiary

Source: Ženka, J. *et al*. 2021; own survey.

To measure the spatial concentration of perceived wayfinding difficulties in the hospital complex (based on the answers of respondents to questions concerning the difficulty of finding a hospital department), we employed the Herfindahl–Hirschmann index, constructed as:

$$HHI = \sum_{i=1}^{n} s_i^2,$$

where s_i is the share of answers (that the hospital department in that pavilion was difficult to find or to be found with some difficulty), we collected in pavilion I in the total number of answers in the hospital complex.

Apart from basic descriptive statistics, we used two kinds of statistical tests: Crammer V and the binary logistic regression model. In the first step, two dependent variables (SmartApp acceptance and Wayfinding difficulties) were associated with the explanatory variable Location to test potential geographical effects on technology acceptance and orientation in the hospital complex. To capture the potential effects of gender, age and education, statistical tests were conducted separately for men and women, people in different age groups, and people with elementary, secondary and tertiary education.

In the next step, we focused on the single most important dependent variable: SmartApp acceptance. A binary logistic regression model has been constructed, with gender, age, education, and the interaction between gender and age as explanatory variables (see the next section for details and interpretation).

Results

Let us start by presenting the selected descriptive statistics of the sample (*Figure 1*). Newcomers and people visiting the hospital after a long time accounted for 44.1 per cent of all respondents. Not surprisingly, the major groups in the sample were middle-aged people (41–60 years old) and the elderly (over 60 years old) who visit the hospital department regularly or often. These respondents may be

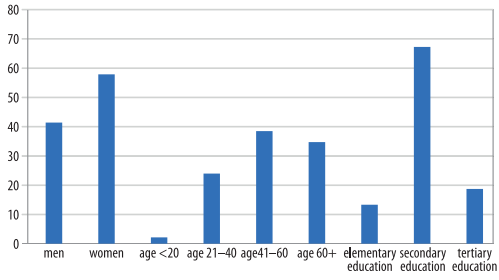

Fig. 1. Basic descriptive statistics of the sample. *Source:* Author's own survey.

more reluctant to use smartphone applications and changes in the navigational system of the hospital. While two-thirds of respondents answered that wayfinding in the Vítkovice Hospital is easy, many of them (31.2%) are regular visitors. Correspondingly, this is also one of the reasons why only 35.4 per cent of respondents affirmed that the navigational system in the hospital needed to be improved (14.1% 'yes', and 21.3% 'rather yes'). Despite the high share of regular visitors and the elderly, 68.9 per cent of respondents are willing to use smartphone navigation in the hospital.

The survey (see Ženka, J. *et al.* 2021 for details) showed that almost 60 per cent of respondents had their smartphones in the hospital (*Figure 2*). Nevertheless, only 46.8 per cent of them would definitely use their smartphone for navigation in the hospital and another 31.3 per cent would use it only if they got lost. While the ownership of a smartphone is higher among women, men are slightly more willing to use it for navigation. In line with our expectations, the willingness to use a smart navigational app was the lowest in the group of 60+ people (below 20%) and highest in the group 21–40 (young respondents below 20 were underrepresented, so their real numbers might be different). More interestingly, the share of patients/visitors refusing to use a smart navigational app is high in all age groups. A positive association between educational level and acceptance of the SmartApp has been found.

The most perceived wayfinding difficulties differed significantly among particular pavilions and departments of the hospital (*Table 2, Figure 3*). Almost half of the answers that the hospital department was rather difficult to find were concentrated in pavilion I, the most remote building from the gateway. Contrary to our expectations, women's perceived wayfinding difficulties were not more spatially concentrated at the level of buildings compared to men. Gender differences in the perception of particular pavilions were rather minor and did not show any systematic pattern. Surprisingly, neither the elderly nor less educated people showed systematically higher perceived wayfinding difficulties than younger and more educated respondents. Perceived wayfinding difficulties of people with elementary education were more spatially uneven than in the case of more educated respondents.

Most of the abovementioned spatial differences in perceived wayfinding difficulties appear to be statistically significant (*Table 3*). These findings apply both for men and women, age groups 21–40 and 41–60, and people with secondary and tertiary education. On the other hand, significant differences in wayfinding among particular pavilions were found neither for people with elementary education nor for the age group 60+. The latter can be explained by more frequent visits to the hospital complex by the elderly. However, the expected gender, age, and education differences were

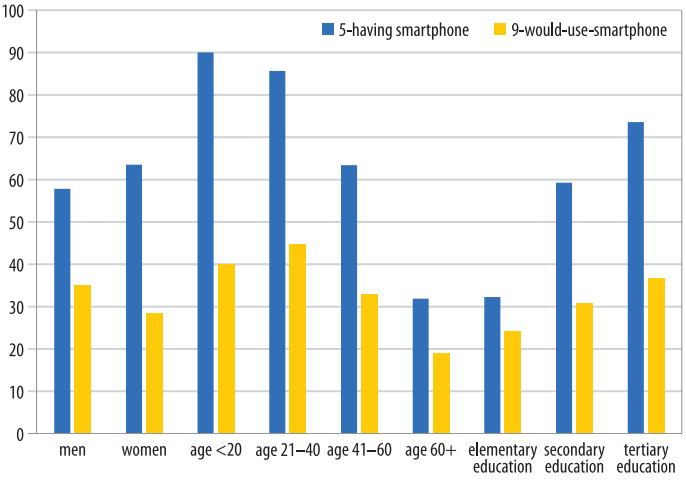

Fig. 2. Share of respondents having/willing to use a smartphone for navigation in the hospital according to gender, age, and education, in per cent. *Source*: Author's own survey.

Table 2. Share of the hospital pavilions in the total number of answers, in per cent*

Variable name	A	B	D	E	F	H1	H2	H3	I	HHI
Gender										
Men	0.0	0.1	6.8	5.1	14.7	0.3	23.8	0.8	48.5	1,984
Women	0.1	0.4	6.9	6.9	19.2	0.8	14.0	1.3	47.4	1,786
Age, years										
21–40	–	33.3	75.0	39.1	29.7	50.0	38.7	42.9	35.6	2,437
41–60	7.7	60.0	70.0	25.0	43.5	35.7	24.4	29.4	46.1	1,875
60 +	22.2	25.0	33.3	36.4	28.4	30.0	25.4	22.2	40.4	2,013
Education										
Elementary	2.4	4.1	2.4	8.9	18.7	0.8	35.0	2.4	25.2	2,322
Secondary	1.8	1.9	5.4	11.0	19.2	3.2	25.4	5.4	26.1	1,894
Tertiary	4.6	1.7	12.1	14.9	14.9	3.4	14.9	2.9	30.5	1,788

*Answers for the whole hospital, that the patients/visitors had difficulty with finding the place. A–I are signs of hospital pavilions, HHI = Herfindahl–Hirschmann index. *Source:* Authors' own survey.

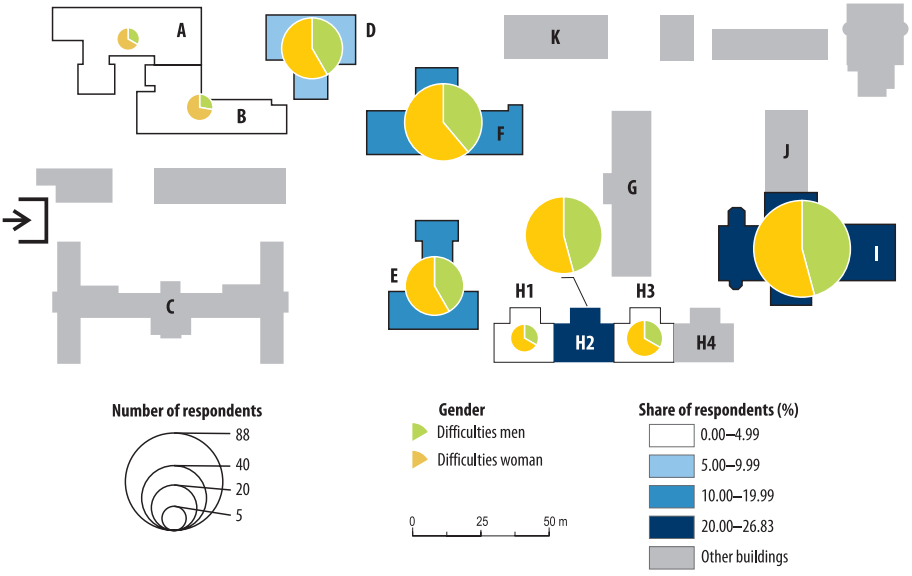

Fig. 3. Spatial distribution of perceived wayfinding difficulties in the hospital complex. *Source*: Author's own survey.

not found. Women, elderly and less educated people do not show higher spatial differences in wayfinding than men, younger and more educated respondents.

More importantly, substantial spatial differences were found also in the rate of SmartApp acceptance. Significant effects of the variable Location on the intention to use a smartphone

Table 3. Spatial differences in perceived wayfinding difficulties and the SmartApp acceptance

Variable name	Location X					
	Wayfinding difficulties			SmartApp acceptance		
	N	V	p	N	V	p
Gender						
Men	384	0.251	< 0.001	382	0.188	0.095
Women	199	0.199	0.020	478	0.200	0.006
Age, years						
21–40	185	0.267	0.049	186	0.207	0.461
41–60	341	0.296	< 0.001	342	0.172	0.454
60 +	318	0.136	0.982	317	0.254	0.005
Education						
Elementary	115	0.271	0.663	117	0.373	0.017
Secondary	588	0.177	0.024	587	0.162	0.062
Tertiary	159	0.424	< 0.001	159	0.276	0.108

Source: Authors' own survey.

for navigation were found in the group of men, women, seniors 60+, and people with elementary education. While not strong, there is a positive association between perceived wayfinding difficulties and SmartApp acceptance at the level of hospital pavilions. Respondents in the difficult-to-find pavilions and departments were generally more keen to use a smartphone for navigation.

In the next step, we tested the effects of gender, age, education, and location on SmartApp acceptance (*Table 4*). We constructed many combinations of regression models, including also all other explanatory variables listed in *Table 1.* These variables, however, did not increase the explanatory power of the model substantially or show a significant effect on the dependent variables. After all pre-tests, we decided to keep the model as simple as possible, including only the variables Gender, Age, Education, Location and interaction of gender, and age (following Venkatesh, V. *et al.* 2012) as the explanatory variables. The dependent variable was dichotomous: intention to use a smartphone application for navigation in the hospital: SmartApp acceptance (yes or no).

Education showed the strongest positive association with the dependent variable: the intention to use a smart application for navigation in the hospital is highest in the group of people with tertiary education. While statistically significant, there were no major differences between men and women: men showed only slightly higher rates of technology acceptance. The model explained a relatively low share of the variability of the dependent variables (16.1%). SmartApp acceptance decreases with rising age; it is significantly lower in the age group 60+. The spatial variable pavilion showed the second strongest effect, reflecting the high share of the remote pavilion in the total number of perceived wayfinding difficulties.

Discussion

We found no major gender gap in the intention to use smart apps for navigation in the hospital: in accordance with Hwang, K.H. *et al*. (2016), or Silber-Varod, V. *et al.* (2019). This contrasts with the traditional digital divide model (Rice, R.E. and Katz, J.E. 2003), which favours males and their higher willingness to use new technologies and overcome the associated difficulties with their adoption. While many respondents (especially the elderly ones) may have no experience with the use of navigation smart apps, these

Table 4. Correlates of patient and visitor acceptance of a smart navigation app

Variables in the Equation						
Step 1*	B	S.E.	Wald	df	Sig.	Exp(B)
N11_Gender(1)	-0.385	0.194	3.929	1	0.047	0.680
N12_Age	–	–	51.456	3	0.000	–
N12_Age(1)	-3.439	1.070	10.334	1	0.001	0.032
N12_Age(2)	-1.859	0.299	38.660	1	0.000	0.156
N12_Age(3)	-0.963	0.194	24.702	1	0.000	0.382
N13_Education	–	–	6.866	2	0.032	–
N13_Education(1)	0.715	0.032	4.647	1	0.031	2.043
N13_Education(2)	0.017	0.240	0.005	1	0.942	1.017
Age_Gender	–	–	0.045	1	0.832	–
Age_Gender(1)	-0.096	0.453	0.045	1	0.832	0.908
Location	–	–	4.812	3	0.186	–
Location(1)	0.137	0.265	0.267	1	0.605	1.147
Location(2)	0.297	0.236	1.582	1	0.208	1.346
Location(3)	0.483	0.229	4.472	1	0.034	1.622
Constant	0.637	0.316	4.055	1	0.044	1.891

*Variable(s) entered on step 1: N11_Gender, N12_Age, N13_Education, Age-Gender, Section_AGR_reduced.
-2 Loglikelihood = 805.946; Cox&Snell R Square = 0.161; Nagelkerke R Square = 0.215. *Source*: Authors' own survey.

technologies are currently not in the early stage of development. Therefore, perceived ease of use – while generally an important predictor of technology acceptance (Davis, F.D. *et al.* 1989; Mehra, A. *et al.* 2020) is probably not a key factor affecting the willingness to use smart navigation apps (Arning, K. *et al.* 2012). Gender differences in some spatial abilities favouring men (Galea, L.A.M. and Kimura, D. 1993; Lawton, C.A. 2001) and higher spatial anxiety/uncertainty of women in the real environment (Lawton, C.A. *et al.* 1996; Mendez-Lopez, M. *et al.* 2020) do not translate into higher demand for smart navigation apps among women (Ženka, J. *et al.* 2021). We, thus, do not confirm the assumption that people who are good at navigating themselves are not in an urgent need to use an indoor navigation system and may be less willing to adopt a smart indoor navigation system (Smirnov, M. 2007; Wichmann, J. and Leyer, M. 2021).

Age was by far the most important factor of technology acceptance, confirming the findings of Rice, R.E. and Katz, J.E. (2003). Technology acceptance decreases with increasing age (Olson, K.E. *et al.* 2011), which was clearly supported also for the case of smart navigation apps in the hospital. Statistical tests of the interactions between age and gender and education showed non-significant results. This is probably caused by the limited number of answers, when disaggregated according to the age/education category and gender, despite using the broadest possible age categories (less than 40 and 40+).

Despite nonsignificant results in the regression models, the interaction between gender and age has effects on the dependent variable: younger males are the most willing to use smart navigation apps, 40+ women the least. Interestingly, gender differences between the younger respondents are much higher than between the 40+ respondents. Therefore, our results contrast sharply with the conclusions of Morris, M.G. *et al.* (2005, 79), who stated that "…gender differences decline dramatically among the younger cohort of workers and a more unisex pattern emerges". We agree with the statement "mobile service adoption and usage may vary significantly among young users, thus, treating them as a homogeneous group is not appropriate" (Rao, S. and Troshani, I. 2007, 68). Smaller gender differences between the 40+ respondents – more frequent visitors to the hospital – may be caused by their higher familiarity with the hospital complex

and perhaps also by generally higher self-confidence in spatial abilities compared to younger people (De Beni, R. *et al.* 2006). In addition, elderly men tend to rely more on established habits, so their technology acceptance is lower compared to younger men (Venkatesh, V. *et al.* 2012).

We found positive effects of education on the SmartApp acceptance in the hospital. In this case, the formal educational level should be viewed as a proxy of general cognitive abilities (see Elias, M.F. *et al*. 1997, or Le Carret, N. *et al.* 2003), spatial abilities (Proust-Lima, C. *et al.* 2008; Ulrich, S. *et al.* 2019), and an intention to gain new (technical) skills. Arning, K. *et al.* (2012) argue that smart navigation technology acceptance is affected by the level of individual technical self-efficacy (TSE), defined as the confidence in one's own ability to solve technical problems. Wichmann, J. and Leyer, M. (2021), on the other hand, found no significant effects of perceived behavioural control, operationalized as the individual perception of own control and the ability to use applications for indoor navigation. Even more importantly, these authors also documented the negative effects of individual spatial abilities on the intention of visitors/patients to adopt an indoor navigation and localization system in the hospital. Our results, however, support the assumption that cognitive abilities, represented in our model of formal education, increase the acceptance of smart navigation technologies. This effect is stronger for younger respondents.

We did not find empirical evidence for our initial assumption that perceived wayfinding difficulties will be more spatially concentrated in the case of women, the elderly, and people with elementary education compared to men, younger and more educated respondents. Principal differences in spatial abilities and orientation strategies (Lawton, C.A. 1994) between men (cardinal directions) and women (landmarks), younger and older (less and more educated) people do not result in significant variations in perceived wayfinding difficulties among the pavilions in the hospital complex. On the other hand, significant spatial differences were found not only in perceived wayfinding difficulties, but also in the intention to use a smart navigation application. The latter finding corresponds with the conclusion of Arning, K. *et al.* (2012) that disorientation is the most powerful predictor of navigation device acceptance.

Conclusions

The main aim of this paper was to determine if hospital patients/visitors intend to use a mobile navigation application. To answer these questions, we conducted a questionnaire survey among 928 respondents in the Vítkovice Hospital in Ostrava, Czechia. Despite the high share of elderly and regular visitors, almost 70 per cent of respondents answered that they accept a smart navigation app in the hospital. We tested the effects of age, gender, education, and location in the hospital complex on individual acceptance of the smart navigation app. Age was the key factor of technology acceptance, which was found to be the lowest in the group of 60+ respondents. Education showed a strong and positive effect on SmartApp acceptance, which was highest among respondents with tertiary education.

No major gender gap in technology acceptance was observed, which supports the previous findings of Ženka, J. *et al.* (2021). The assumptions of the unified theory of technological acceptance that gender differences are more pronounced in older age groups were, thus, not supported by empirical evidence. On the contrary, respondents 40+ were more homogeneous in their answers than their younger counterparts, while men below 40 were much more willing to use the smart navigation app than women in the same age group. The higher homogeneity of the 40+ age group might be explained by the familiarity of many (especially elderly) respondents with the hospital complex be-

cause they are relatively frequent visitors of the Vítkovice Hospital complex.

Finally, the location was another major factor of perceived wayfinding difficulties and SmartApp acceptance for navigation in the hospital. We confirmed the finding of Arning, K. *et al.* (2012) that disorientation is a strong determinant of navigation device acceptance. On the other hand, we did not get sufficient empirical evidence for our assumption that general gender/age/educational differences in spatial abilities and navigational strategies translate into the specific spatial pattern of perceived wayfinding difficulties and technology acceptance in the hospital complex. There were no major and systematic gender/age/educational differences among particular hospital locations (pavilions, departments). Surprisingly, in the group of people 60+ relatively small variations in perceived wayfinding difficulties among the hospital pavilion/departments were found. This could be explained by relatively frequent visits and, thus, a high familiarity with the hospital complex.

Future research on technology acceptance should develop a further link between the spatial factors and the intention to use a smart navigation device. Empirical evidence shows that disorientation in complex buildings and compounds increases people's acceptance of smart navigational devices. However, little is known about the mechanisms and interactions with other nonspatial factors, such as gender, age, and individual cognitive abilities.

If we turn to some practical implications of our research, the findings suggest the importance of efficient navigational cues located near the entrance to the hospital complex. The perceived wayfinding difficulties of respondents were spatially concentrated mostly in the most remote pavilion in the hospital complex, which is obscured by other buildings. Therefore, differences among other pavilions/departments in landmarks and other navigational cues were of minor importance. A key factor for wayfinding success was the ability to form a cognitive map of the whole hospital complex. In small hospitals, the navigational system should focus on cardinal directions and the presentation of the entire hospital complex.

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Anomalies of precipitation and drought in objectively derived climate regions of Iran

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Abstract

By regionalizing precipitation in 113 synoptic stations in Iran, the characteristics of precipitations and the occurrence of droughts in each region were investigated over a period of 30 years, 1988–2017. Elevation, latitude and distance from moisture source have caused strong East–West and South–North gradients of precipitation across the territory of Iran so that the average annual precipitation increases from 55 mm in the eastern and central regions to 1,730 mm in the south-west coast of the Caspian Sea. Hierarchical cluster analysis identified six precipitation regions in Iran, including the arid, semi-arid, moderate, semi-humid, humid, and high humid regions. An investigation of the standardized precipitation index (SPI) showed that the trend in about 19 per cent of stations was significantly decreasing. It was non-significantly decreasing in 65 per cent, significantly increasing in less than 1 per cent, and non-significantly increasing in 15 per cent of the stations. While the occurrence of drought has increased in most parts of Iran, it has decreased in some stations only in the northern strip of the country. The line slope in more than 84 per cent of the stations represent negative values in SPI, which confirms an increase in the occurrence of droughts in Iran.

Keywords: hierarchical cluster analysis, anomaly of precipitation, drought trend, Iran

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Introduction

Natural environmental conditions have a great impact on the economic and social infrastructure of human societies, and climate is one of the most important factors in this regard. The role of precipitation in climatic conditions is very vital due to the supply of required water resources. Although precipitation is a complex and highly variable element, climate change has increased its variability. Climate change means a change in the average climate or its variability over an extended period. With an increase in greenhouse gas emissions in recent decades, climate change has become known as increasing temperatures and consequently global warming. Although climate change includes all climatic conditions, changes in temperature and precipitation are more evident. Many climate change studies have indicated that annual rainfall in the subtropical regions may lead to decrease in the current century (Dai, A. *et al.* 2018). Meteorological drought is a persistent decrease in precipitation below the average in a region over a period of time (Dai A. 2011; Hao, Z. and Singh, V.P. 2015; Gulácsi, A. and Kovács, F. 2018). The occurrence of droughts has influenced the availability of water resources (Szabó, S. *et al.* 2019), especially in water-limited regions. Reduced availability of water resources affects all aspects of human life, such as the environment, agriculture and food security, and it can cause significant losses to human societies (Somorowska, U. 2017).

Iran is a dry land territory that mainly receives very little rainfall (Ghaedi, S. and Shojaiean, A. 2020). Under the influence of the Azores high-pressure subtropical system, precipitation is close to zero in most parts of

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the country during the warm period of the year (Ghaedi, S. 2021). Low rainfall has led to the formation of very large deserts in the East (the Kavir and Lut deserts) and in the South of the country with less than 100 mm of rainfall. Iran's population has increased from about 22 million in 1960 to more than 83 million in 2020. An increase of about 400 per cent in the population in the last 60 years has increased the need for drinking water, and industrial and agricultural projects. The purpose of building large dams in Iran is to store water resources gathered in rainy periods for periods of low rainfall. However, these dams also create problems for downstream water supply and dry up wetlands and lakes. Evaporation from the surface of lakes behind the dams is very high in hot regions such as Iran and causes a waste of abundant water resources. Due to an increasing temperature trend in most stations of Iran (Zarei, A.R. and Masoudi, M. 2019), the rate of evaporation from these lakes has also increased over the time. The use of groundwater resources has also increased significantly in the last few decades (Darijani, F. *et al.* 2019), and the rate of abstraction has been much higher than the rate of water infiltration into the deeper layers. Overall, global warming, severe rainfall anomalies, persistent droughts, growing population, and, most importantly, weakness in the management of water resources have put a lot of pressure on water resources (Nouri, M. and Homaee, M. 2020).

A number of studies have investigated the anomaly of precipitations and droughts in Iran from different aspects. Some have focused on specific regions (Tabari, H. *et al.* 2012; Rostamian, R. *et al.* 2013; Zarei, A.R. *et al.* 2016; Zarei, A.R. 2018; Zarei, A.R. and Masoudi, M. 2019; Moghbeli, A. *et al.* 2020). Others have investigated sub-regions with distinct climatic conditions, impact on the environment and agriculture (Daneshvar, M.R.M. *et al.* 2013; Aliabad, F.A. and Shojaei, S. 2019), and impact of climate change (Khajeh, S. *et al.* 2017). Further studies have covered the whole country with a limited number of stations (Abarghouei, H.B. *et al.* 2011; Amirataee, B. and Montaseri, M. 2017; Nouri, M. and Homaee, M. 2020), while others have dealt with drought risk assessment (Daneshmand, H. and Mahmoudi, P. 2017; Sharafi, L. *et al.* 2020), and modelling, prediction and trend assessment of drought (Modarres, R. *et al.* 2016; Bahrami, M. *et al.* 2019).

In the present paper, the precipitation regions of Iran were first zoned using the average annual precipitation. Then, the anomaly of precipitations and meteorological droughts were studied in the precipitation-based regions.

Data and methods

This study investigated anomalies of precipitation and droughts over Iran. With an area of 1,648,195 km^2, Iran is a relatively large territory in South-west Asia, located between approximately 25°N and 40°N and 45°E and 64°E. The main humid sources of precipitation in Iran are the western (Mediterranean cyclones) and south-western (Red Sea trough) systems in the cold season and the south-eastern (Gang low pressure) system in the warm season (Degirmendžić, J. and Kożuchowski, K. 2017). The Zagros Mountains in the West and the Alborz Mountains in the North, as well, as other vast water bodies (i.e. the Persian Gulf and the Oman Sea in the South and the Caspian Sea in the North) have caused a great deal of spatial climatic diversity in Iran.

Data

The first meteorological station in Iran was established in 1929. After that, the main stations at provincial centres have been recording meteorological data since 1950. To apply data in climatological studies, in addition to the statistical period, it is necessary to pay attention to the area of the region, the variety of topography, and the climatic conditions in the proportional distribution of stations in the region under study (Ghaedi, S. 2019). In this study, monthly precipitation data of 113 stations were used for the period 1988–2017 *(Figure 1).*

Fig. 1. Digital elevation model (DEM) of the study area and location of the synoptic stations

Methods

A hierarchical cluster analysis was performed to regionalize the annual precipitations in the meteorological stations of Iran, which had data for the whole 30 years. Based on the agglomerative multivariate statistical technique of cluster analysis, datasets and/or large amounts of decreasing data are classified into subgroups or dendrograms, which make different possible groups easily visible and manageable (Fazel, N. *et al.* 2018). It is assumed that if there is a precipitation gradient in the region, differentiated clusters following different geographical directions can be obtained from this analysis. Initially, a dissimilarity matrix is created. Then, each object is placed in a special cluster. After that, based on the distance matrix, two similar objects are joined together, and this operation continues until a single cluster is created. There are different methods for data linking, but due to the fact that in many climatological studies, Ward's linkage has been considered as an appropriate one, this technique was used in the current study. To calculate the distance matrix, the Euclidean distance method was used. The number of clusters is determined by the researcher, and the number of acceptable and fairly homogeneous clusters can be obtained by varying the number of clusters. The silhouette width method was used to assess the homogeneity of the clusters, i.e. the clusters' quality (Lengyel, A. and Botta-Dukát, Z. 2019). This graphical method helps to interpret the clusters. The purpose of this is to assess the accuracy of the placement of objects in their cluster and to check whether it is possible to change the cluster of an object.

Several indices have been developed in recent decades to determine the severity and duration of droughts. McKee, T.B. *et al*. (1993)

proposed and developed the standardized precipitation index (SPI), which is currently one of the most widely-used indices to quantify meteorological drought. SPI determines periods of positive or negative precipitation anomalies over a given region using precipitation data for a selected timescale. Simply, meteorological drought is the strong decrease in precipitation over a period of time in a specific region relative to the long-term average precipitation of that region. Finally, this difference is standardized by dividing it by standard deviation (Amirataee, B. and Montaseri, M. 2017) (see Eq. 1).

$$SPI_i = \frac{P_i - \bar{P}}{\delta}, \quad (1)$$

where SPI_i represents the drought index, P_i is the precipitation value in period i^{th}, and $\bar{P}$ and δ are the mean of precipitation and standard deviation of precipitation, respectively.

In order to accurately assess drought indices and to determine dry and wet periods, a classification including seven categories of extreme drought (-2 or less), severe drought (-1.99 to -1.50), moderate drought (-1.49 to -1.00), mild drought (-0.99 to 0), mild wet (0 to 0.99), moderate wet (1.00 to 1.49), very wet (1.50 to 1.99), and extreme wet (2.00 or more) was presented.

Continuous meteorological drought leads to hydrological drought and, as a result, surface water resources (rivers, lakes, etc.) and groundwater levels are significantly decreased.

Parametric and non-parametric methods can be used to determine significant trends in climatologic time series. Non-parametric trend tests require data to be independent, while parametric trend tests in addition require that the data be independent they must have a normal distribution. Mann–Kendall and Sen's slope estimator as two non-parametric methods were used to detect the meteorological variables' trends in this study.

The Mann–Kendall (MK) test was used to calculate precipitation and drought trends during the study period. Based on this non-parametric method, if the standard normal test statistic (Z parameter) at 95 per cent confidence level is more or less than 1.96/-1.96, it indicates a significant increase/decrease in time series, respectively. If the Z value is between 0 and 1.96, the increase is non-significant, and if it is between 0 and -1.96, it indicates a non-significant decrease in the data trend.

The Mann–Kendall test only determines the trend and its direction, but it does not show the magnitude of the trend line. Therefore, the Sen's slope estimator technique (reference, please) is used to determine the numerical value of the line slope along with the Mann–Kendall method. This non-parametric method involves computing slopes for all the pairs of ordinal time points by applying the median of these slopes as an estimate of the overall slope.

Results and discussion

The annual precipitation

The average annual map of precipitation *(Figure 2)* shows that precipitation across Iran varies with the highest values in the northern and the lowest values in the eastern and central regions. According to *Figure 2*, precipitation surfaces for each year for the period 1988–2017 show that there is also variability in the pattern of precipitation across Iran between the years.

Regionalization by cluster analysis

The survey of precipitation surfaces in each of the years of the study period illustrates that there is intense variability in the precipitation pattern of all regions of Iran. However, the north-south and West–East gradients persist throughout the year, the spatial distribution of precipitation changes from year to year. According to precipitations in all stations in the study period, in the years 1991, 1992, 1993, 1994, 1996 and 2004, the rainfall was more than the third quarter and in the years 1990, 2000, 2001, 2008, 2010, 2013 and 2017, it was less than the first quarter.

Cluster analysis and the resulting dendrogram chart demonstrated that six clus-

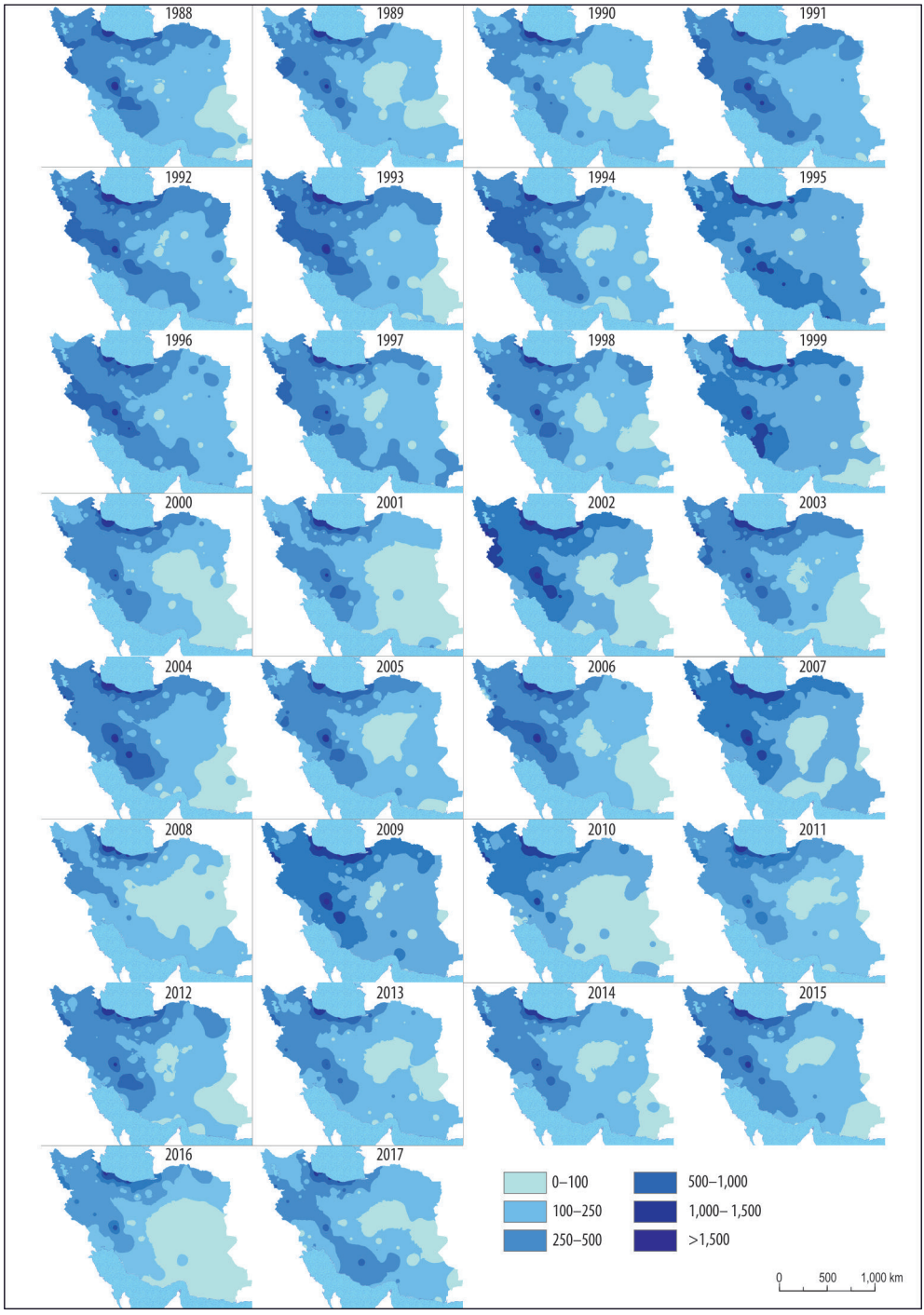

Fig. 2. The average annual precipitation (mm) for each year (1988–2017) across the studied region

ters could be identified at the stations in the studied period. The cluster spatial distribution is presented in *Figure 3*, and, as is hypothesized, the resulting groups follow the precipitation gradient across the region.

Clusters A to F are the driest to the wettest precipitation regions of Iran, which can be called arid, semi-arid, moderate, semi-humid, humid and high humid, respectively. The study of the spatial distribution of clusters indicates that the three factors of elevation, latitude and distance from the large water bodies, especially from the Caspian Sea, determine the resulted clusters. The wettest clusters are related to the south-western shores of the Caspian Sea (E and F) and to the heights of the Alborz and Zagros mountains (C and D). All regions of the eastern half of the country, except the heights of the northern regions and a small area in the South (Lalehzar Mountain), include the arid parts of Iran (A). Low altitude, distance from western moisture sources (the Mediterranean Sea and the Red Sea) and being located in the lee side of the Alborz and Zagros heights have decreased rainfall in these regions. In the margins of arid and foothill areas, semi-arid areas are observed (B). *Figure 3* illustrates the average annual precipitation for each cluster in the studied period (1988–2017).

Trend of precipitation

The results of the Mann–Kendall trend test illustrate that the majority of stations under study decline in the annual precipitation totals for the extended period of 1988–2017, which is consistent with previous studies (Some'e, B.S. *et al.* 2012; Najafi, M.R. and Moazami, S. 2016). From the 113 stations under study, 95 stations

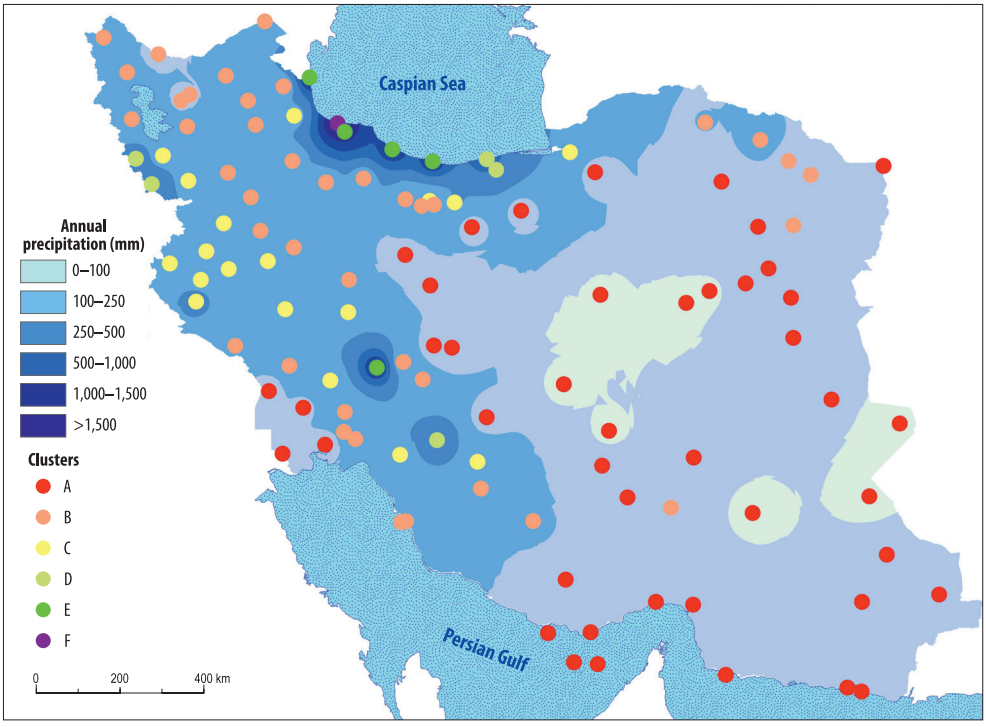

Fig. 3. Annual precipitation average and spatial distribution of clusters (A–F) resulted from the hierarchical cluster analysis

(84%) show decreasing trends, among which 21 stations have significant decreases considering a 5 per cent level of significance (*Figure 4*, left). Significant decreases occur in the East and West of Iran as well as in the central regions of the country and the south-east of the Persian Gulf. Spatial heterogeneity of precipitation trends is due to complex topography or other environmental conditions such as wind direction, the physical condition of the ground surface, topographic direction, water resources, etc. Hence, in some adjacent stations, such as the stations in the North, north-east and south-east, opposite trends have occurred.

Figure 5 represents the average annual precipitation per year for each cluster. Despite the relatively large variability in the point-wise precipitation during the studied 30 years, the

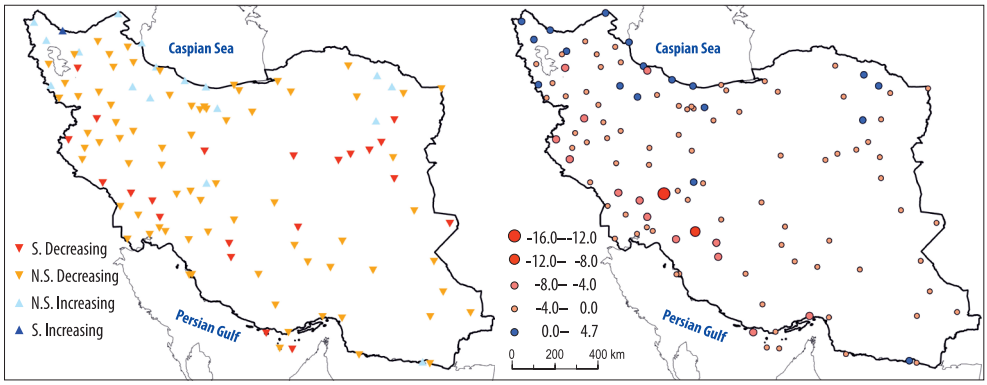

Fig. 4. The annual precipitation trend (left) estimated based on the Mann–Kendall test considering a 5 per cent significance level and Sen's slope estimator of precipitation (right). N.S. means non-significant in the left part of this figure.

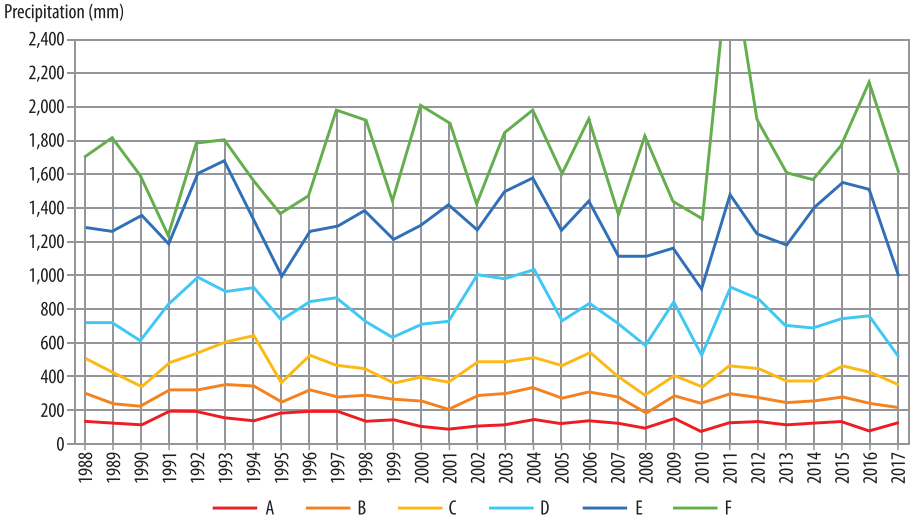

Fig. 5. Mean annual precipitation (mm) totals in clusters A–F, 1988–2017

interval of precipitation amount averaged for the clusters has been stable among the years, and relative coordination is observed in the precipitation anomalies so that they occur almost simultaneously in all clusters.

Variability of drought events

The spatial and temporal variability of drought events for the period 1988–2017 is presented in *Figure 6* using the SPI method based on a 12-month time step. The most severe droughts were observed in 1990, 2001, 2008, 2010, 2016 and 2017 when many parts of the country experienced mild to severe droughts.

The time series of the SPI for each precipitation clusters are presented in *Figure 7.* It can be observed that the performance of SPI is almost the same in all precipitation regions. The most severe droughts have occurred in highly humid (cluster F) and semi-humid (cluster D) regions in 1991 and 2017, respectively, and in 2010, 2013 and 2017, when the SPI index was negative in all clusters. Although in these years the SPI index is positive in the limited regions, but the average of all clusters is negative. The severity of the 2010 drought is higher than in 2013 and 2017. Wetter years (1992, 1993 and 1996) can also be identified in these maps. These years were also identified as wetter than average years by Dashtpagerdi, M.M. *et al.* (2015). Ahmadi, M. *et al.* (2019) believe that in 1992 and 1993 the composite synoptic patterns includes Pacific: warm, Atlantic: cool and Indian: cool have increased precipitation over Iran.

Trend of droughts

Figure 8 shows the results of SPI intensity trend based on the application of Mann–Kendall test (left) and its line slope according to Sen's method (right) for the magnitude of the trend. The Mann–Kendall test revealed a significant decreasing trend in SPI in 18.6 per cent and a non-significant one in 65.5 per cent of all regions. In the semi-humid to high humid areas, non-significant decreasing trends were observed. The SPI trend was non-significantly increasing (except for Jolfa station in north-western Iran, having a significant increasing trend) for 15 per cent of the surveyed stations, which are mostly situated in the northern strip of Iran *(Table 1).*

The results obtained from Sen's slope technique (*Figure 8*, right) illustrate the slope is negative in most stations with its range varying between 0 and -0.073. In the western and eastern regions, the slope shows larger negative values. In 16 per cent of the stations, which include regions in the northern part of the country and two stations in the centre (Isfahan) and south-east (Kenarak, Chahbahar), the slope is positive.

Conclusions

This study was conducted to better understand the precipitation anomaly and the occurrence of drought in Iran in each of the precipitation-based regions. The average annual precipitation in Iran varies from 51 mm in the eastern and central regions to 1,730 mm in the south-western shores of the Caspian Sea. To gain a more comprehensive insight into precipitation variability, cluster analysis methods were performed. Hierarchical cluster analysis of annual precipitation data of the studied stations showed that six precipitation clusters could be identified in Iran. The clusters from the driest to the wettest regions were named as A to F, respectively. The identified clusters illustrated that the precipitation pattern mostly followed the topography, latitude and distance from humidity sources, i.e. the Caspian Sea, the Red Sea, and the Mediterranean Sea.

In 2010, 2013 and 2017, the SPI index was negative in all clusters, which indicated a widespread drought in all regions of Iran. In some years (1990, 1995, 1999, 2005, 2007 and 2008), drought has occurred in five of the six clusters of precipitation regions of the country. The most severe drought in the period under study is related to 2010 when the SPI index showed large negative numbers in all parts of the country.

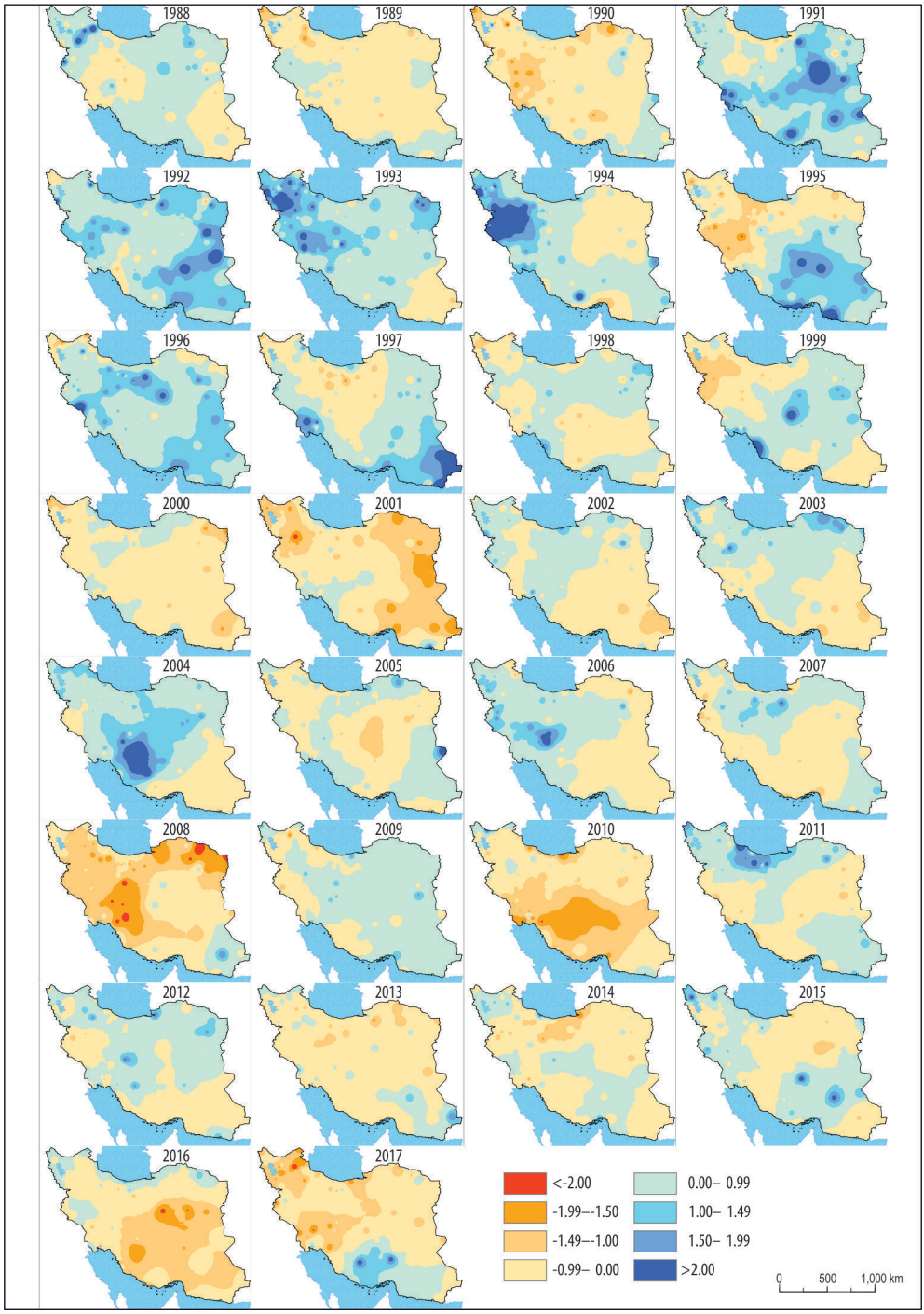

Fig. 6. The 12-monthly SPI values in each year of the studied period

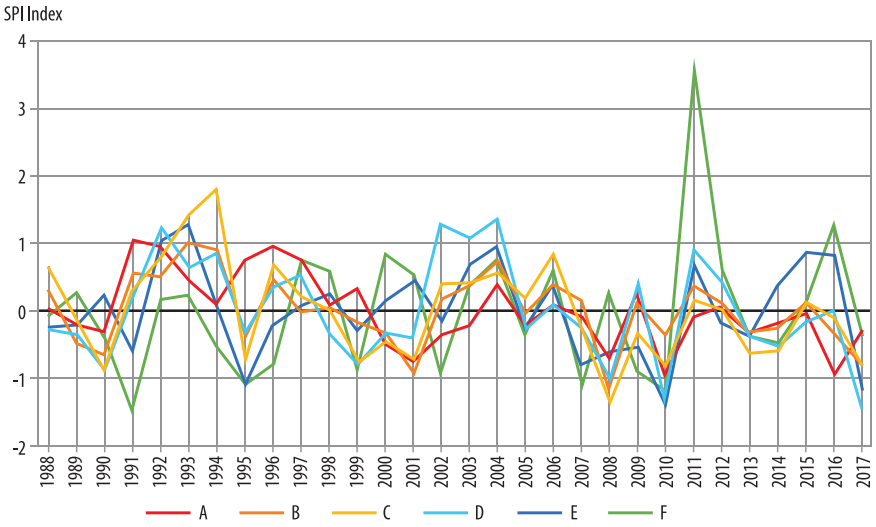

Fig. 7. SPI chart for 12 months in each cluster (A–F) and year, 1988–2017

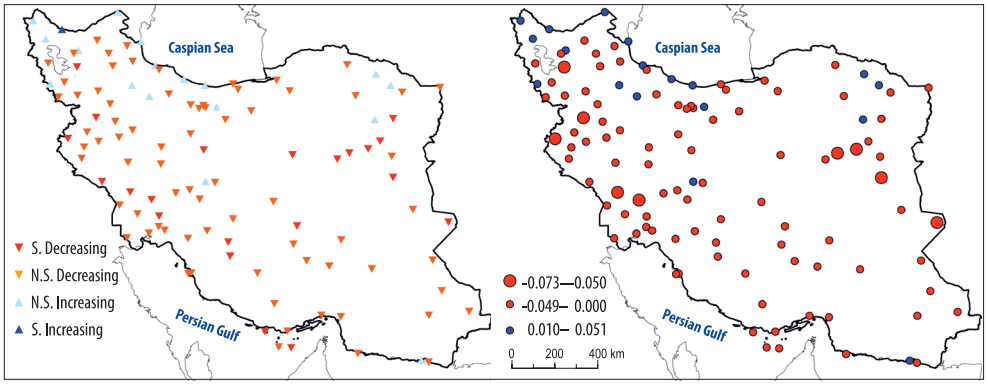

Fig. 8. The annual drought trend (left) estimated based on the Mann–Kendall test considering a 5 per cent significance level and Sen's slope estimator of drought (right)

The significance of linear trends and the line slope for annual series data of total precipitation were tested using Mann–Kendall test and Sen's slope estimator, respectively. An overall decline was observed in the total annual precipitation, particularly in the stations located at latitudes below 36°N. An overall declining slope was detected in the frequencies of the annual precipitation across Iran. However, a mixture of increasing and decreasing trends in the northern belt of the country was observed.

Table 1 comprehends the properties of precipitation and drought in any clusters. The driest cluster (A) to the wettest cluster (F) can be named as arid, semi-arid, moderate, semi-humid, humid and high humid, respectively.

From cluster A to F, the standard deviations among the clusters (from spatial aspect) have been increasing; therefore, increasing rainfall

Table 1. Statistics of trend and line slope in the studied station, 1988–2017

Clusters	Trend				Line slope	
	Decreasing		Inceasing		Negative	Positive
	S.	N.S.	S.	N.S.	slope	
A	11	30	–	3	41	3
B	6	25	1	8	31	9
C	4	13	–	1	17	1
D	–	4	–	1	4	1
E	–	2	–	3	2	3
F	–	–	–	1	–	1
%	18.6	65.5	0.9	15.0	84.0	16.0

Table 2. Characteristics of precipitation regions of Iran

Cluster	Climate conditions	Average annual precipitation	Precipitation S.D.	No. of drought years	Mean Sen's slope
A	arid	131.6	33.0	16	-1.60
B	semi-arid	274.5	78.5	14	-1.30
C	moderate	442.0	115.0	14	-3.38
D	semi-humid	777.3	181.8	16	-3.14
E	humid	1,309.0	279.4	15	-2.63
F	high humid	1,730.0	325.8	15	4.70

has led to an increase in the standard deviation of the regions *(Table 2).* With increasing variability in precipitation, the risk of planning increases in the fields of water resources, agriculture and the environment, and, as a result, water resources must be managed more carefully. The number of years of drought occurrence in all clusters is almost equal and varies between 14 years (B and C) and 16 years (A). The line slope values in all clusters except the high humid region are negative, while the highest negative slope (-3.38) is related to the moderate region, and the lowest negative one (-1.3) is related to the semi-arid region. The passage of high pressures formed in northern Iran (August to November) over the warm waters of the Caspian Sea has caused heavy rainfalls, especially on the south-western coast of the sea.

Studies of the water temperature of the Caspian Sea in recent years have shown that the surface temperature of the water has increased significantly (Khoshakhlagh, F. *et al.* 2016), which justifies the positive slope of precipitation in the high humid cluster (Anzali port in the south-western part of the Caspian Sea).

The results of this research are in agreement with Zarei, A.R. (2018), who studied the trends and patterns of drought over the south of Iran and Daneshvar, M.R.M. *et al.* (2013) that investigated the drought hazard impacts on wheat cultivation in Iran.

The findings of the study on the spatial and temporal variability of precipitation and drought occurrence over Iran are important and useful for the accurate identification of the sub-regions' hydrology and agriculture and for better planning of water resources in all parts of the territory.

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Directional analysis of drainage network and morphotectonic features in the south-eastern part of Bükk Region

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Abstract

The fracture deformations often result in linear morphological elements (lineaments, valleys) on the surface. In many cases, the direction of the lineaments and valleys can be well followed by the strike of the geological structural elements. Therefore, conclusions can be drawn from these directions for regional tectonic processes. Our work aimed to analyse the relationship between the valley and lineament network and the structural elements in the south-eastern part of Bükk Region. We prepared the theoretical drainage network map and lineament map of the area. The direction of the linear elements was examined separately on the eastern part of South-Eastern Bükk that is built up mainly by Mesozoic limestone and the eastern side of Bükkalja area covered by Neogene and Quaternary sediments. Structural geological surveys were also performed on seven sites to measure the strike of joint sets. These results were compared with the valleys' direction in the 2 km wide area of the measurement sites. Based on our results, it can be stated that the development of the drainage network was influenced by the geological elements; however, there are local differences in the characteristics of the South-Eastern Bükk and Bükkalja. Our study confirmed that the study of linear morphological elements has great importance in the exploration of geological structural elements.

Keywords: drainage, lineament, directional analysis, structurally controlled streams, tectonic preformation, morphotectonics, Bükk Mountains, Bükkalja

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Introduction

On the surface, faults often cause linear geomorphological structures called lineaments (Twiss, R.J. and Moores, E.M. 1992; Jordán, Gy. and Csillag, G. 2003; Radaideh, O.M.A. *et al.* 2016). In the dissected zones weakened by faults, the erosion is more effective, therefore valleys often form along with these structural elements (Martz, L.W. and Garbrecht, J. 1992). Besides the valleys, lineaments can be geomorphological units like ridges, escarpments (Twiss, R.J. and Moores, E.M. 1992; Jordán, Gy. and Csillag, G. 2003; Radaideh, O.M.A. *et al.* 2016). Measuring and analysing the direction of lineament and drainage network is important, because we can infer the directions of the main strike of geological structural elements (Twiss, R.J. and Moores, E.M. 1992; Eyles, N. *et al.* 1997). Mapping lineament and drainage network is relevant both in geomorphological and structural geological research because these are in association with the regional structural processes (Ramsay, J.G. and Huber, M.I. 1985; Twiss, R.J. and Moores, E.M. 1992; Centamore, E. *et al.* 1996; Eyles, N. *et al.* 1997; Jordán, Gy. and Csillag, G. 2003; Dombrádi, E. *et al.* 2007; Ruszkiczay-Rüdiger, Zs. *et al.* 2007, 2009; Radaideh, O.M.A. *et al.* 2016; Gioia, D. *et al.* 2018).

The structural evolution of the south-eastern part of Bükk Region was directed by varied ge-

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ological processes since the Eocene (Csontos, L. 1988, 1999; Márton, E. and Fodor, L. 1995; Less, Gy. *et al.* 2005; Németh, N. 2005; Petrik, A. *et al.* 2014, 2016). Some of these processes caused the development of structurally preformed valleys. Some valley sections of Tárkány-, Eger-, Ostoros-, Kánya-, Hór-, Tard-, Kács-, Sály-, and Kulcsárvölgy stream were formed along faults (Schréter, Z. 1912, 1926, 1933; Balogh, K. 1963; Less, Gy. *et al.* 2005; Németh, N. 2005; Petrik, A. 2016; Pecsmány, P. *et al.* 2020; Pecsmány, P. and Vágó, J. 2020). In the northern part of Bükk Region and its northern foreland Szalai, K. (2004) proved the structurally preformed characteristics of the valleys by direction statistical analysis.

Our hypothesis is that the structural characteristics directed the geomorphic evolution of the South-Eastern Bükk Region and the development of the area's drainage network. In this paper, we proved the relationship between the geological structural elements and the linear elements (lineaments and valleys) by direction statistical analysis.

Research area

Location

Based on the official Hungarian landscape classification, the research area (291 km^2) is situated in the south-eastern part of the Bükk Region, microregion group of the North Hungarian Mountain Range region (Csorba, P. *et al.* 2018). The north-western part of the area (65 km^2) belongs to the mountainous microregion of South-Eastern Bükk (Hevesi, A. 2003), the south-eastern hills (226 km^2) are located on the eastern part of Bükkalja foothills microregion (Csorba, P. *et al.* 2018), while the north-eastern part is the western side of the Sajó Valley. The boundary of the microregions can be drawn along the fault lines between the Mesozoic and Cenozoic rock formations (Dobos, A. 2002). Two sub-mountain basins can be found at this boundary with different geological features and geomorphological landscapes; the Kács Basin and the Kisgyőr Basin (*Figure 1*) (Hevesi, A. 2003; Pecsmány, P. 2017).

Geology and geomorphology of the research area

The geomorphology (Hevesi, A. 1978, 2002a,b; Hevesi, A. and Záhorszki, A. 2000) and the geological characteristics of the South-Eastern Bükk (Csontos, L. 1988; 1999; Pentelényi, L. 2002; 2005; Németh, N. 2005) and the Bükkalja (Dobos, A. 2002; Vágó, J. and Hegedűs, A. 2010; Petrik, A. 2016; Pecsmány, P. 2017) are well known. However, the eastern side of Bükkalja has not yet been examined in details from a geomorphological and geological point of view. The average height above sea level is 250 m. The relative relief is 130 m/km^2 of the whole research area, but there is a significant difference between the geology and geomorphology of the mountainous and hilly parts.

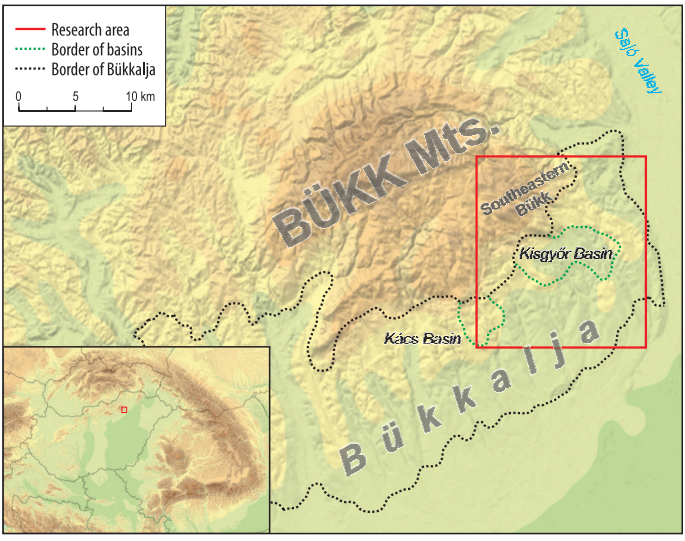

Fig. 1. Location and topography of the research area

South-Eastern Bükk area

The average height above sea level is 472 m, with the highest point is 719 m, the lowest one is 129 m a.s.l. The relative relief is 212 m/km^2. This mountainous region is mainly composed of strongly karstified Triassic limestone (Berva Limestone, Bükkfennsík Limestone) with dolines, sinkholes, cave springs and less karstified cherty limestone (Felsőtárkány Limestone) without dolines and caves (Hevesi, A. and Záhorszki, A. 2000; Less, Gy. *et al.* 2005). Triassic metavolcanic rocks (Szentistvánhegy Metavolcanics, Szinva Metabasalt) can be found in the northern part of the area. In some places, there is saccharoidal dolomite (Belvács Dolomite), Jurassic shale (Lökvölgy Formation) and radiolarite (Bányahegy Radiolarite Formation) on the surface (*Figure 2*; Less, Gy. *et al.* 2005).

Bükkalja area

The average height above sea level is 185 m. The highest point is 505 m, the lowest one is 104 m above sea level. The relative relief is 95 m/km^2. Cenozoic deposits cover these Mesozoic rocks in the area of the Bükkalja due to vertical fault displacements (Balogh, K. 1963; Less, Gy. *et al.* 2005; Németh, N. 2005; Petrik, A. 2016). The main rock types are Eocene limestone and calcareous marl (Szépvölgy Limestone), Oligocene clay and clayey marl silt (Buda Marl, Kiscell Clay) in the North (Less, Gy. *et al.* 2005); variable-stability Miocene pyroclastics (sometimes ignimbrite) produced by the periodic volcanic activity (Lukács, R. *et al.* 2018) (Gyulakeszi Rhyolite Tuff Formation, Tar Dacite Tuff, Harsány Rhyolite Tuff) in the middle (Less, Gy. *et al.* 2005); sedimentary rocks of former Lake Pannon (Egyházasgerge Formation, Sajóvölgy Formation, Zagyva Sand, Edelény Clay) in the South (Less, Gy. *et al.* 2005) (see *Figure 2*). Due to the differential weathering of volcanic tuffs, there is sandy, gravelly colluvium (*grézes litées*) on the gentle slopes (Pinczés, Z. *et al.* 1993), which was often re-

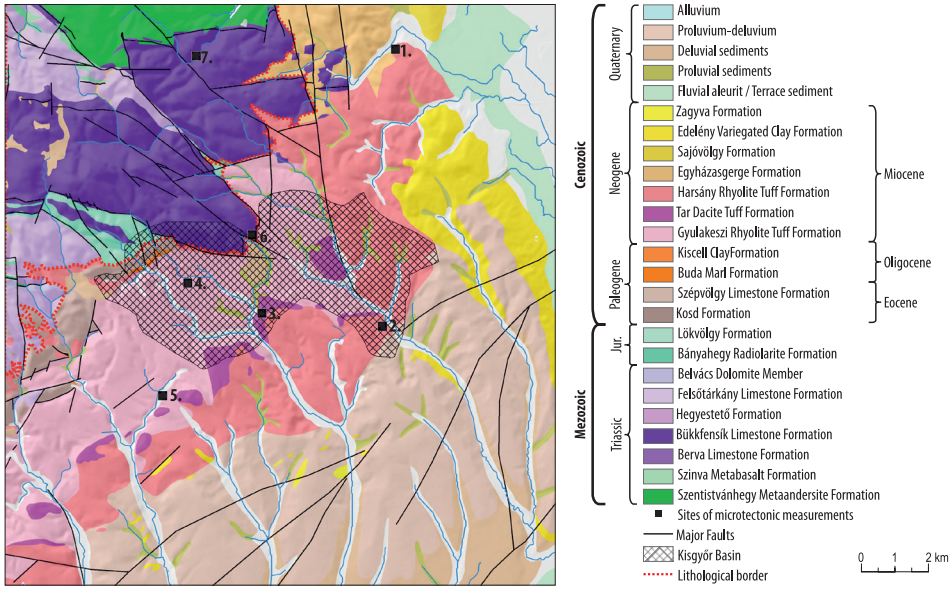

Fig. 2. Geological map of the research area (Gyalog, L. and Síkhegyi, F. 2005), major faults (Less, Gy. *et al.* 2005; Németh, N. 2005; Petrik, A. 2016) and the sites of microtectonic measurements

deposited by fluvial erosion and downhill mass movements. South of the tuff outcrops, with a gradual decrease in clay content, loess, resedimented loess, sand, gravel is typical (Less, Gy. *et al.* 2005; see *Figure 2*).

Materials and methods

The drainage network of the research area

In areas where drainage density is low (such as in Bükkalja), instead of the streams, the valleys are often used for direction statistical analysis in structural morphological research (Martz, L.W. and Garbrecht, J. 1992; Ruszkiczay-Rüdiger, Zs. *et al.* 2007, 2009). The valleys were extracted from a digital elevation model using ArcGIS "Fill", "Flow Direction" and "Flow Accumulation" tools. The DEM (cell size: 25 × 25 m) was interpolated using digitized contour lines and elevation points of topographic maps scale 1:10,000. In our research, we considered only those DEM pixels as parts of valleys, which have a catchment area bigger than 150 pixels (~0,1 km^2). Then we vectorised the valley pixels, this polyline network draws the valley network. Since the orientation of the valley network was compared with the deep structural elements' direction, the smaller oscillations of valley sections were smoothed by the Demeter, G. and Szabó, Sz. (2009) method, applying the ArcGIS "Generalization" tool. Using the breakpoints (vertices) of the valleys, we split each curve to straight line segments. The distances of vertices as valley length, and the coordinates of these vertices were used for the calculation of the direction of the segments, applying the RockWorks 16 software. The valley sections' Strahler-orders (Strahler, A.N. 1957) were defined by the ArcGIS "Stream Order" tool. The directions and direction frequencies were plotted on rose diagrams with 10-degree scale interval using RockWorks 16 "Creating Rose Diagrams from Endpoint Data" tool. The rose diagrams were analysed by traditional visual interpreting methods (Ricchetti, E. and Palombella, M. 2007; Radaideh, O.M.A. *et al.* 2016; Petrik, A. and Jordán, Gy. 2017; Gioia, D. *et al.* 2018).

Lineament mapping

There are many methods to identify and digitize lineaments. Visual interpretation of satellite images (Leech, D.P. *et al.* 2003; Unger, Z. and Timár, G. 2005; Al-Rawashdeh, S. *et al.* 2006), digital elevation models and its derivatives (Radaideh, O.M.A. *et al.* 2016; Petrik, A. and Jordán, Gy. 2017), or both of them together (Chaabouni, R. *et al.* 2012) is usually applied, but subjective technique. Striving for objectivity, in our research, we used the method published by Al-Obeidat, F. *et al.* (2016) for mapping lineaments. This method analyses the hillshade, a DEM derivative as an image by a Canny edge detection algorithm. Hillshades were created in ArcGIS 10.1 software, and then the edge detection algorithm was run on them in MatLab R2017b software. The result rasters were vectorised in ArcGIS 10.1. Then the polylines were smoothed using ArcGIS "Generalization" tool. Only lines longer than 500 m were considered lineaments (*Figure 3*) because these are more likely associated with fault lines than shorter ones. Directions and direction frequencies of lineaments were plotted on rose diagrams.

Microtectonic measurements

Microtectonic observations were made during field trips. In this study, measurements of subvertical joints were used only. Dip data of 925 faults/joints were measured in 7 exposures (see *Figure 2*) by a Freiberg-type geologic compass and Field Move Clino IOS mobile application (Smith, S. *et al.* 2014; Lundmark, M.A. *et al.* 2020) (without declination correction). Strike frequency was plotted on a rose diagram with a 10-degree scale interval using RockWorks 16 software. It is important to note that not only the spacing but also the exposure

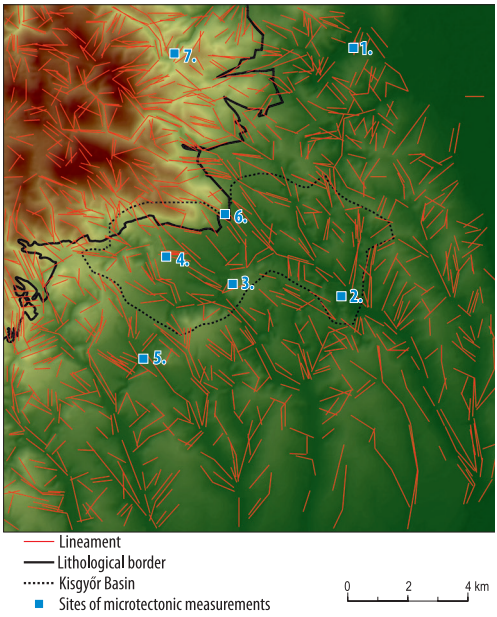

Fig. 3. Lineament map created by the method of Al-Obeidat, F. *et al.* (2016).

orientation of the site influences the number of measurements on joints if differently oriented joint sets (e.g. in the case of a with E–W oriented section, the number of detected N–S joints will be much higher than of the E–W striking ones). Therefore, in contrast with the topographic lineaments, differences of actual magnitude in local maxima on the diagrams may reflect this and not the relative abundance of the joints belonging to the joint sets characterized by a certain orientation.

Results

Strike of faults and other planar structural features

We wanted to compare the directions of the morphological linear elements and the mapped (Less, Gy. *et al.* 2005; Németh, N. 2005; Petrik, A. 2016) and measured (Petrik, A. 2016) geological structural elements; therefore, we also examined their directional statistics.

The direction frequency of the planar structures mapped so far in the area shows a bimodal distribution. The E–W and N–S directions are the most common. Even in direction frequency weighted by length, a bimodal character can be observed in the N–S and NW–SE directions (*Figure 4*). In the Bükkalja, Petrik, A. (2016) measured ESE–WNW and NW–SE conjugate normal faults and joints strikes, NE–SW trending dextral and NW–SE sinistral strike-slip, E–W strike reverse faults.

Drainage network and lineament directions of the South-Eastern Bükk and Bükkalja area

The direction and direction by length of the valleys are E–W on the South-Eastern Bükk area. On the lineaments' diagrams, the major direction is between E–W and NW–SE (*Figure 5*).

On the Bükkalja area direction frequency of the valleys is undirected, however, the direction by length-frequency shows a dominantly NW–SE direction. The dominant directions of the lineaments on the foothill area are NW–SE and N-S (see *Figure 5*).

Direction frequency and direction frequency by the length of the valleys by their order

Analysing the direction frequency (per cent of the total population) of the valleys by their order on the entire research area, it can be stated that the 1st order valley sections are undirected (*Figure 6*).

In the case of 2nd order valleys, the primary direction is the E–W, but many of the valley sections have a NW–SE direction. Most of the 3rd order valleys have a N–S direction; however, the most common direction by the valley length is NNW–SSE. In the case of 4th order valleys, the main direction is NW–SE (*Figure 6*).

We also analysed the valley network separately on the South-Eastern Bükk and Bükkalja area. In the South-Eastern Bükk, the 1st and 2nd order valleys have E–W direction, while the direction of 3rd order sections

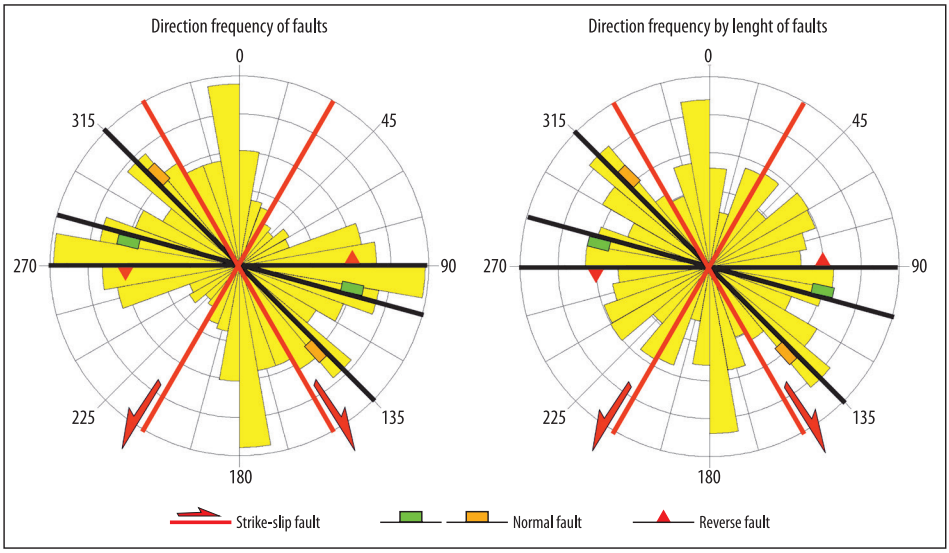

Fig. 4. Faults direction from geological map with Petrik' s (2016) Pannonian–Pleistocene simplified fault kinematic

is N–S. In the direction frequency by length, the 1st order valleys are undirected, the 2nd order sections have E–W direction, and the 3rd order ones have N–S direction (*Figure 7*).

In the Bükkalja area, both the direction and direction by the length of the 1st order valleys is undirected. In case 2nd order valleys, the main direction is E–W. There is also a secondary, NW–SE direction, which is the main direction on frequency by length diagram. The main direction of 3rd and 4th order valleys is NW–SE in case of both direction, and direction by length (see *Figure 7*).

Valley, lineament and joints strike directions of the microtectonic measurements sites

Within a radius of 2 km around all structural measurements sites, we examined the directions of the lineaments, valleys and joints (*Figure 8*).

The direction and direction by the length of the valley network is NW–SE, except the neighbourhood of measurement sites No. 2 and No. 7. Site No. 2 has a NNE–SSW dominant and a NW–SE secondary direction. In the case of site No. 7, the main direction is E–W, however, the NW–SE direction can be seen as well on the diagram see (*Figure 8*).

The lineaments' direction at site No. 1 and No. 2 is NNE–SSW, NW–SE at sites No. 3-6, while E–W at site No. 7. The directions of joints at the measurement sites No. 1, 2, 3, 5 is NE–SW, NNW–SSE at site No. 4, ESE–WNW at site No. 6, and N–S at site No. 7 (see *Figure 8*).

Discussion

The principal direction of the valleys coincides with the direction of the dominant aspect (Vágó, J. 2012), transverse faults (Pecsmány, P. 2021), and Pannonian–Pleistocene conjugate normal faults and joints strike (Petrik, A. 2016) (*Figure 9*).

Relevant differences can be found in the directions of linear elements on the South-Eastern Bükk and Bükkalja area. The valleys of the South-Eastern Bükk, running on limestone, dolomite, metavolcanics and shale are grouped around the E–W direction. The

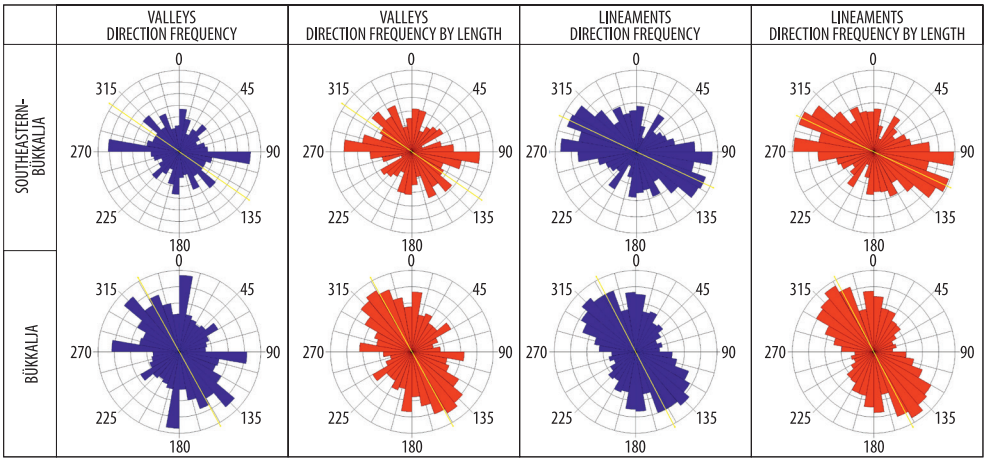

Fig. 5. Drainage network and lineament directions of the South-Eastern Bükk and Bükkalja area

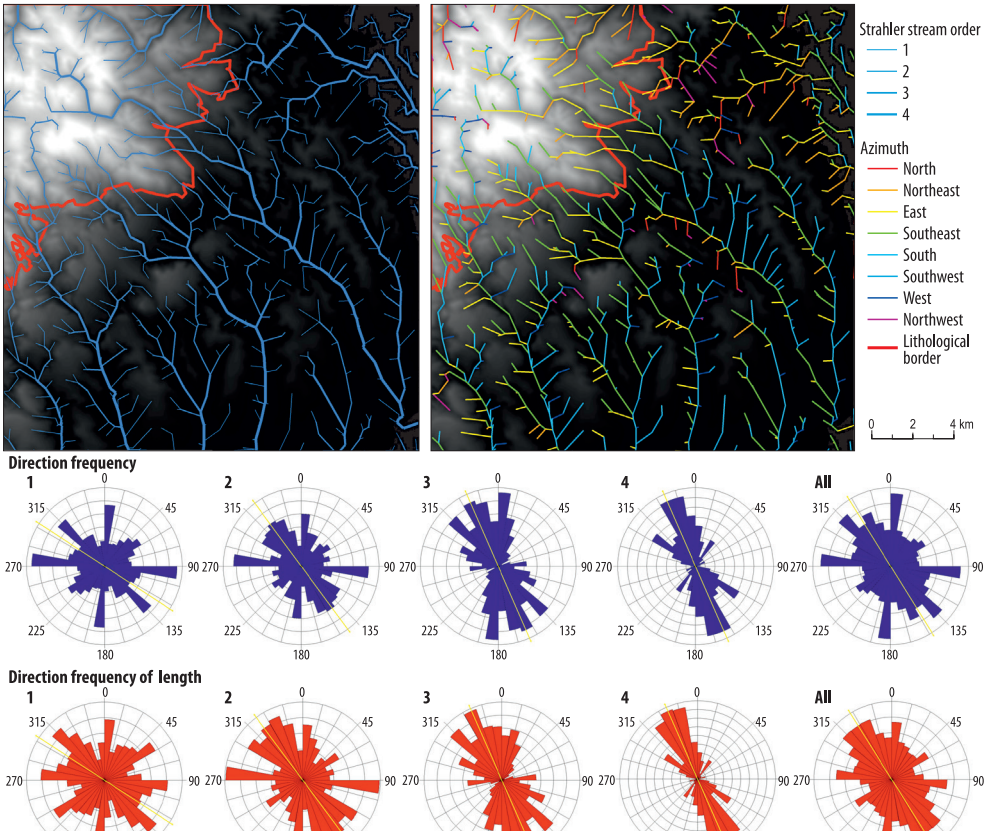

Fig. 6. Direction frequency of the valleys by their order on the entire research area.

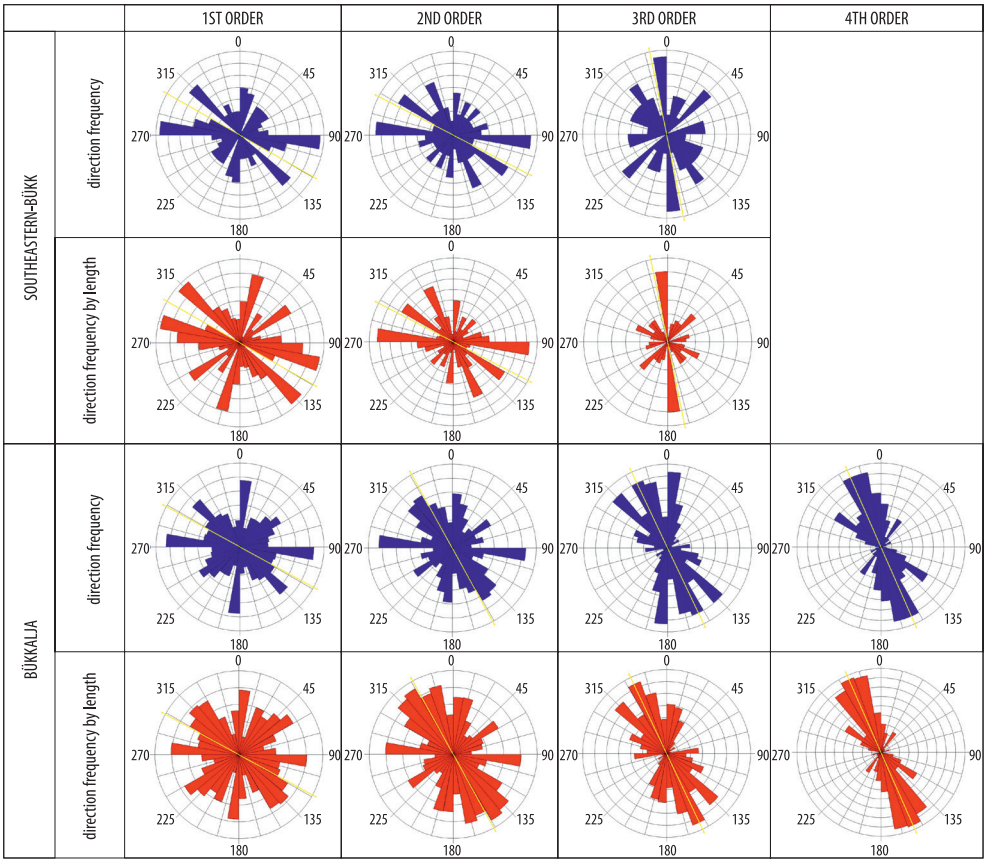

Fig. 7. Direction frequency and direction frequency by length on the South-Eastern Bükk and the Bükkalja area

direction of the foothill drainage network, running mostly on Miocene pyroclastics and Quaternary sediments, is almost "perpendicular" to this, N–S, NNW–SSE (see *Figure 5*).

The difference can also be observed for lineaments. The direction of the linear elements detected on the South-Eastern Bükk is between E–W and WNW–ESE direction. In the foothill area, the measured values are grouped around the NW–SE direction (see *Figure 5*). Similar to Ricchetti, E. and Palombella, M. (2007) and Radaideh, O.M.A. *et al.* (2016), we found that the direction frequency by length provides more reliable results.

Most valleys run more or less parallel to the cardinal directions, while the total length of the valleys has NW–SE direction (see *Figure 6*). The reason is that a large number of shorter, low-order valleys run parallel to the cardinal directions. In contrast, in the NW–SE direction less, but longer high-order valleys tend to run.

The direction frequency and the direction frequency by the length of the 2nd, 3rd and 4th order valleys of the Bükkalja area are the same as the directions measured over the entire area (*Figures 6* and *7*). However, in the case of South-Eastern Bükk, there is a difference. Most of the 1st order valleys are oriented to the E–W direction, weighting by the valley sections' length the dominant directions are WNW–ESE and the NNW–SSE (see *Figure 7*). The 2nd order valleys have

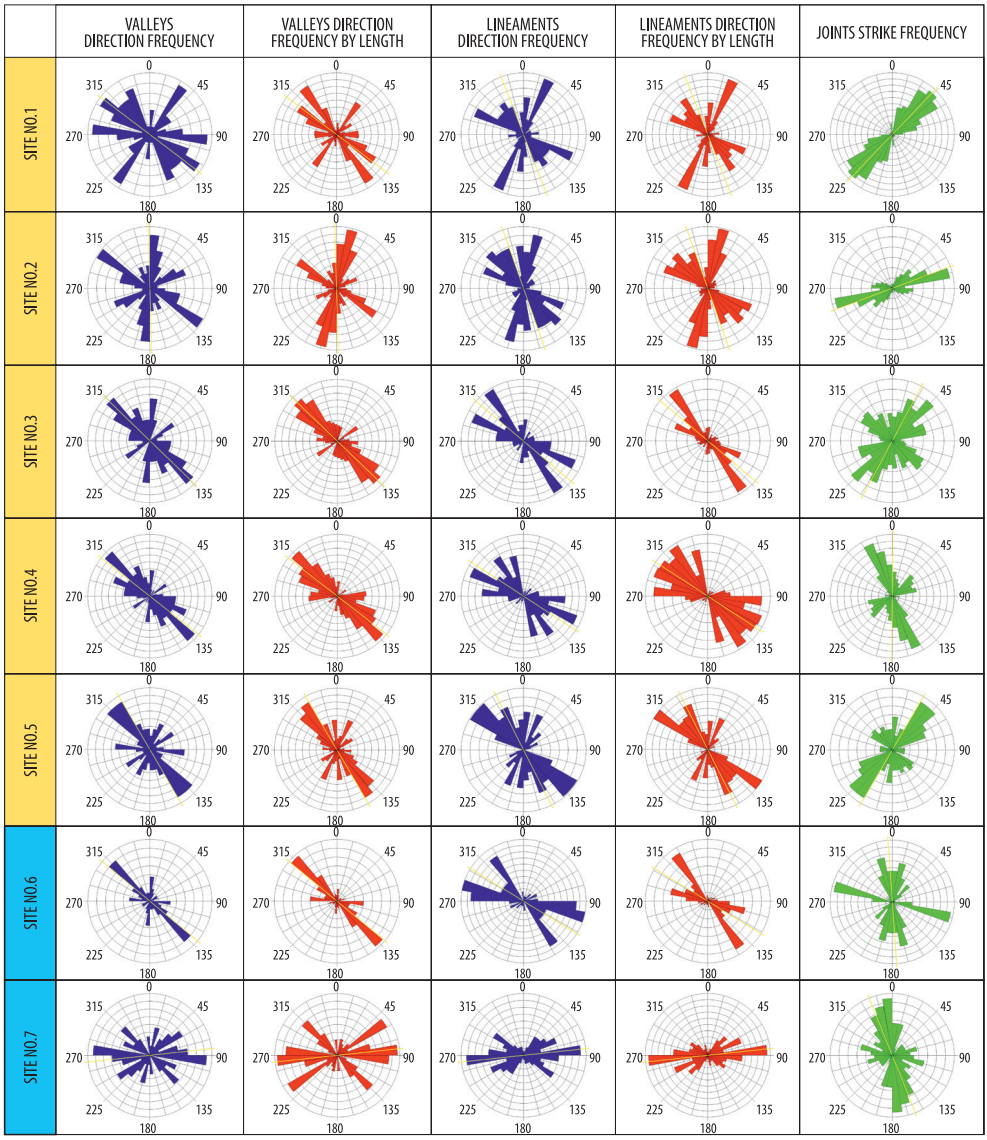

Fig. 8. Direction frequency and direction frequency by the length of valleys, lineaments and joints strikes at the measurement sites

mostly E–W direction. The most common direction of the 3rd order valleys is N–S (see *Figure 7*).

In the South-Eastern Bükk, the 3rd order valleys coincide with the main direction of the mapped geological structural elements. In the Bükkalja, the 2nd, 3rd, 4th order valleys follow well the secondary direction of the mapped geological structural elements (see *Figure 4*). The undirected characteristics of 1st order valleys on the Bükkalja can be explained by the valley density. This value is higher on the Bükkalja (1.5 km/km^2), than in the South-Eastern Bükk (1.3 km/km^2).

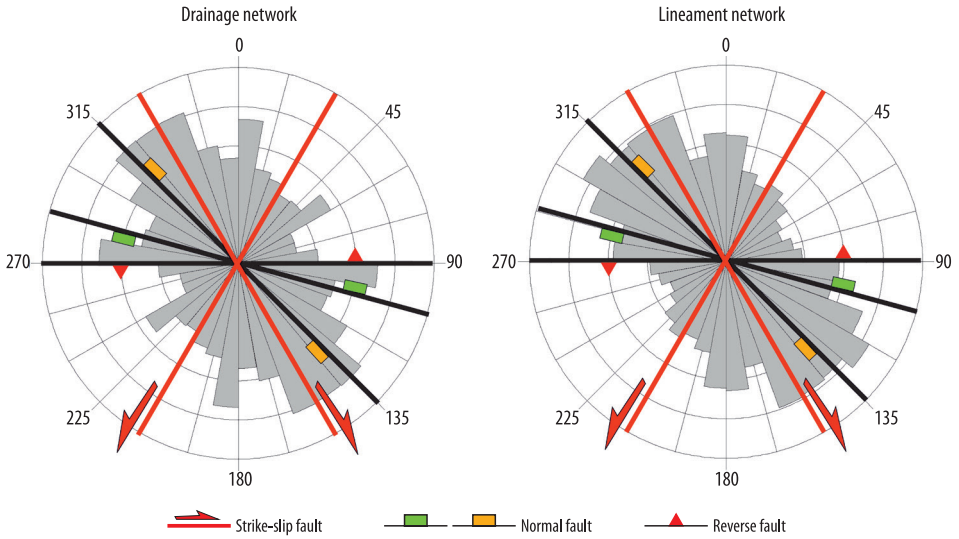

Fig. 9. Direction frequency by length of drainage and lineament network with Petrik's (2016) Pannonian–Pleistocene simplified fault kinematic

According to Centamore, E. *et al.* (1996), the streams with lower order are directed by the recent tectonic activity, while the higher-order streams are following directions of the trending geological structural elements. In our study area, the directed/undirected characteristics of the low-order valleys were strongly influenced by the rock quality. However, the directions of the higher-order valleys coincide with the characteristic geological structural directions of the area. The result of the direction statistical analysis depends on the geological settings (rock quality) and the scale of valley order mapping.

The direction of joint sets strike coincides with the direction of valleys and lineaments (see *Figure 8*: site No. 1, 4 and 6) with a ~15° angular displacement. Most of the measured joint sets can be found in Miocene pyroclastic rocks, which petrographic characteristics are diverse on the Bükkalja (Less, Gy. *et al.* 2005; Pentelényi, L. 2005; Lukács, R. *et al.* 2018). The differences in rock quality may cause such angular displacements (Demeter, G. and Szabó, Sz. 2009).

Conclusions

Our primary hypothesis was that structural movements determine the study area's surface development and drainage network formation. We analysed the directions of the valleys and lineaments and joint set strikes.

We found that the directions of the valley network coincide with the direction of the mapped and measured structural elements; however, there may be relevant local differences.

Despite the direction coincidence on the entire research area, there is a relevant difference between the drainage- and the lineament networks of the South-Eastern Bükk and the Bükkalja foothill area. Most of the lineaments and valleys are running in W–E direction on the South-Eastern Bükk, while those running on the foothill are in NW–SE direction. There is also a difference in the direction of valley order segments. In the Bükkalja area, most of the 2nd, 3rd and 4th order valleys run in NW–SE direction, while in the South-Eastern Bükk the direction of 2nd order valleys is E–W, while the 3rd order val-

leys run in N–S direction. The reason for this phenomenon requires further investigations.

Based on our examinations, it can be concluded that the structural development of the region strongly influenced the formation of the drainage network of the research area.

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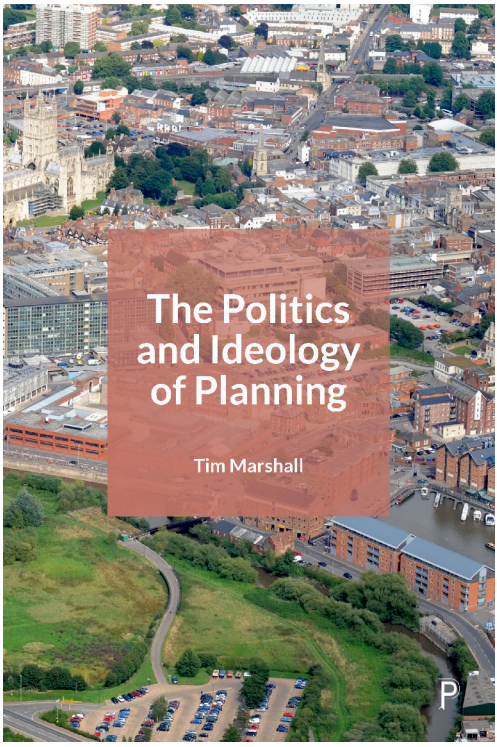
BOOK REVIEW SECTION

Marshall, T.: The Politics and Ideology of Planning. Bristol, Policy Press, 2021. 282 p.

In recurring times of global crises, political-economic theorisations increasingly seek to understand powerful processes that reshape contemporary societies. Economic destabilisation and experienced growing inequalities deeply affect the complexity of social relations and lead to profound ideological instabilities. These turbulent paths shake the validity of hegemonic understandings of politics, economy and society, and often result in the rise of populism. Political scientists eagerly analyse the rise of new dominant narratives, prognosing possible future scenarios that either generate the growth of right-wing Conservatism, the survival of neoliberalism after its hegemonic peak, or else a socialist tide to manage uneven development and take back control on public expenditure.

Tim Marshall contemplates specifically the above and takes an endeavour in the course of UK planning from a historical point of view, where periods of political-economic restructuring left their mark on how the profession is seen as a whole. Even though the book promises a methodological approach to planning, it does more by arguing against its technical nature that dominates the profession. In doing so, the book elaborates on the role of politics and ideology in shaping planning models at all scales. The book employs a compelling approach to engage with debates on both material forces and the role of ideas that shape contemporary planning practices. By bringing the examination of ideology to the forefront of the analysis, it reveals what ideology is, what its effects are, and how it shapes theories of planning. Although the book describes planning processes that apply to the UK, the experienced dynamics are not limited to its territory, but acquires a much broader relevance.



The Politics and Ideology of Planning explores carefully how politics and ideology shape the 'normal' view of planning. The book argues that "planning has been too long buried under various forms of timidity or caution or professional defensiveness" (p. 3). It is separated into 11 chapters, with the first two introducing the topic based on an extensive literature review and explaining the relevance of studying how politics and ideology infiltrates planning throughout history, linking it with a review of British ideologies in Chapter 3. The following two chapters focus on the exploration of British planning history and the role of law in planning. Chapters 6, 7 and 8 highlight the differences of ideology and politics appearing in government, at both central and local level, while also explaining how ideology and politics are becoming more and more detached from the profession of planning via actions of lobbying, pressure groups, or the media itself. Chapters 9 and 10 offer examples with varying levels of ideological load. While heritage, local environment, and design constitute the more cultural debate, housing, economy and infrastructure rather involve structural debates, hence it is the more critical aspect of planning, when hegemonic views can be challenged. Lastly, in Chapter 11, Marshall offers ways forward and some guidelines on how to approach a better path of planning that also offers solutions to today's most burning natural and built environment issues.

As the introduction and subsequent chapters demonstrate, Marshall instrumentalises a 'double-headed' approach, in which politics and ideology is taken into consideration alongside each other throughout the whole book. Politics is understood both as stemming from pressure politics, but also as the every-

day functioning of state, governments and law. Meanwhile, ideological amalgams are represented in both large historical trajectories and normal, shorter time-scale political processes, which are conditioned by material and cultural forces. Taking the composition of these two, the politicisation and ideologisation of planning are mediated through pressure politics and governmental and state institutions, affecting each field of planning and the scale in which it operates. Altogether, it creates a mix of politically and ideologically affected planning. Marshall follows a 'low-theory' political economy approach, as he devotes the book to be at a reduced level of abstraction, and rather focuses on visible realities through 'ordinary' political science. Accordingly, both structural and cultural explanations serve as the basis of inquiry.

In the first half, the book focuses on the development of dominant discourses and narratives. Ideological shifts are taken under scrutiny employing a binary division, comparing what constitutes as classical 'Left' and 'Right' in politics and ideology. More broadly, this refers to progressive, mainly liberal and socialist ideologies on the one hand, and conservative ideologies on the other. The timescale of the investigation stretches from the dawn of the 20th century until contemporary times, providing a historical overview of planning that has been a somewhat neglected attempt in recent undertakings. The *long durée* analysis is separated into five larger periods, which I will pinpoint in the following as four crucial tipping points of capitalist development.

First, the volume covers the birth of planning as a profession, following its brief development from the start of the century, towards the end of the second World War. Foundations were gradually set up, ending in the 1947 Planning Act that functions as a cornerstone of the ideology of planning at the time. The Act regulated that owners could no longer build or develop land without granted planning permission, symbolising the social-democratic approach to planning that characterised the genesis of planning.

Second, the hegemony of neoliberalism is explored, starting in 1979 with the Thatcherite era, when council housing was transferred to commercially driven housing associations as an emblematic moment. The hegemony of neoliberalism started to develop around this time and ended its peak at the global financial and economic crisis of 2008. The conservative ruling that lasted from 1979 towards the end of the 1990s provided a far-lasting challenge to the status quo through introducing a 'fresh' ideological agenda. During this time there was a clear-cut difference among socialist and conservative ideologies. Without doubt, the greatest shift stems from the increasing force of neoliberal ideology that gained ground in both sides of politics, first through Thatcherism after 1979 and later through New Labour after 1997, and only ended its peak at the global financial and economic crisis of 2008.

Third, during the post-1990s to 2010 period the socialist block started to change as well: Tony Blair represented this shift in 1994 by laying out the foundations of Third Way politics (Giddens, A. 2013). Socialist discourse majorly disappeared from the party and after 1997 from the government as well. The Left waited up until 2015 to bring these discourses back by Jeremy Corbyn with a more interventionist approach. In addition, since the 1960s green ideology and environmentalism also had an effect on politics and were very commonly used from the 1990s onwards, with a mix of feminist and multiculturalist discourses.

Finally, in the latest era, lasting between 2010–2015, conservatives and liberal democrats took the leading role. The major changes included the outsourcing of council planning to the private sector, so instead of locally employed planners working with local councillors, the contractualisation of the private sector removed the possibility for largely any public or community input. Furthermore, harsh austerity measures, centralisation and cutbacks on the responsibilities of local governments characterised this era.

Moving on to the second half of the book, Marshall engages with a political-economic approach to look at the structural changes over time. Empirical cases exemplify the spread of entrepreneurial policies, which further included the perception of planning as a merely knowledge-based activity with a technical scope, strengthening the argument that planning can be purely detached from political and ideological dimensions. The centralism of both Left and Right was a heavy driver of this process, especially in the approach to the role of local governments. While the Thatcher conservatism empowered central government on the expense of local governments as independent actors, the 2010s seen the massive slimming down of local government resourcing. Equally, New Labour version of Labourism was not especially sympathetic to local governments, having a similar faith in mind by strengthening the role of the private sector in housing and many other spheres, turning their back to the municipal socialist side of Labourism.

The book defines four major political-economic consequences of 'centralist' politics. First, planning has seen the rise of 'consultocracy' (Parker, G. *et al*. 2019), reducing the scope of democratic local steering of planning. Mike Raco studied the extensive commercialisation of planning through the management of the 2012 Olympics in London (Raco, M. 2014, 2015), where democratisation in general and public input of elected councillors in particular were weakened from the very early stage of the project development. Second, financialisation unfolded through the restructuring of lobbying by privatisation and deregulation (Harvey, D. 1982), generating mass amounts of wealth based on a deregulated regime. Furthermore, property plays a crucial part to this system. Thus, planning is one of the major spheres

where the real negative effects become obvious by repeatedly occurring crises. Third, the entrepreneurialisation of planning showed its true colours as large corporations could more and more easily overcome local opposition, or even disregard planning controls, as showed in the case of Tesco's involvement in the planning system through various tactics, popularly known as a David and Goliath struggle (Simms, A. 2007). Lastly, the importance of the national level is continuously being reinforced by the pressure coming from interest groups and lobbying, instead of being curtailed or counteracted by it. As a result, the loosening power of the local level over local development is an inherent part of centralist politics.

Taking into consideration the aforementioned processes, the book synthesises the narrative and political-economic side of planning, by distinguishing facets and fields of planning, in which certain developments have a less pronounced ideological character, while some planning matters are more subject to political and ideological pressures, as they are close to core issues of maintaining a capitalist system. There are issues that are non-threatening categories neither to conservatism nor to liberal and left ideologies, which both sides of politics are comfortable to promote. These apprehend to the *zeitgeist* of middle-class interests and typically touch upon localised needs, namely heritage, local environment, or elements of design. As Marshall explains, these are not close to the core of capitalist systemic forces, and do not address basic ownership or property structures, or investment conditions. He calls these "other kinds of ideological conditioning" (p. 194) that are close to the perception of cultural changes, involving sensibilities and mentalities. All these elements are related to the culturalisation of urban policies, understandings about nature, places, or cultural heritage, not being necessarily close to dominant growth concerns. Ideological conditioning is less strong in these cases, and short-term politics play a more definite role. However, these are not completely independent from growth concerns, they are also tied up with material forces. The other three fields – housing, the economic sector and infrastructure – imply a greater attention to ideological framings. These issues take a more explicit side when it comes to the question of hegemonic position, whether private provision is the best option, and how goods and services are offered to society. There is a greater scalar change in the decision-making processes of these issues, and all have been going through radical centralisation over the years, losing local control, while the three facets are easier to keep on the local level. Therefore, taking side on how these fields should develop also imply that debates are ideologically more loaded.

In the closing chapters, the book offers an outline of possible scenarios for the post-2020 situation. Borrowing Stahl's (2019) conception following Gramsci, Marshall suggests that there are periods when particular projects are hegemonic, and periods with certain 'interregnums,' in which hegemonic projects are competing with each other. Past the hegemony of neoliberalism, the book resides at a preferable future outcome that involves two crucial elements. As a first element, the need for acquiring a 'radically new imaginary' is highlighted. It incorporates the core values of feminist and green ideologies into mechanisms and values based on socialist ideals. Instead of considering them as a complete formula, these are more fluid over time, developing towards the right direction and right decisions. The basis of such an imaginary contains the confrontation of rising xenophobic nationalism, an economic programme that addresses housing and basic material needs and includes the promotion of the foundational economy (Foundational Economy Collective, 2018). The second element refers to the democratic dimension of ideology. As democratic deficit spreads over all scales: the EU, national, regional and local neighbourhood level, structural changes will need to intersect with the democratisation of practices at all these levels.

To conclude, the book raises a number of questions that are related to debates on current processes of political and ideological pressures in the seemingly technical nature of the planning profession. Even though the study is applied to the UK context, the volume offers a thorough method of analysis in several ways, which might be fruitful also to think about urban planning through elsewhere (cf. Bodnár, J. 2001; Robinson, J. 2016; Roy, A. 2016). One of the major strengths of the book lies in its *long durée* analysis, which makes it possible to highlight larger structural changes and the space-producing logic of capitalism's different cycles. It reveals how changing institutional arrangements and discourses permeate different scales, and how they brought closer together Left and Right ideologies through entrepreneurial strategies in urban regeneration. As it has already been observed (Hubbard, P. and Hall, T. 1998), the entrepreneurial turn offered the local cooperation by the development of local identity for the left, while it supported the belief in the power of the private sector to achieve economic and social benefits on the right. Second, the book did a great effort in untangling the material-discursive nature of planning practices and how these features define the functioning of planning in political economy and social life. Describing this dual nature of planning in a multi-scalar approach adds a substantial layer to the debate about how the urban form comes about.

Finally, the book can be seen as a somewhat cautious Trojan horse for a cultural political economy of planning – keeping distance from more complex theoretical considerations – but much less hesitant in pointing out ways forward. In times of the eruption of the global COVID-19 pandemic, when a sudden macro-structural destabilisation followed, opportunity has also risen to

the victims of systemic failures to open up to and experiment with new, community-based actions towards a long-term solution to both economic and ecological problems. Society across the globe responded to the crisis of welfare, capitalism, and the climate with self-organisation and mutual assistance based on solidarity alternatives. The pandemic has once again highlighted dysfunctional processes of economic insecurity, increasingly precarious livelihoods and housing conditions, and even a more widespread care and food crisis, to which only a socialist-based green and feminist ideological education could serve as a panacea.

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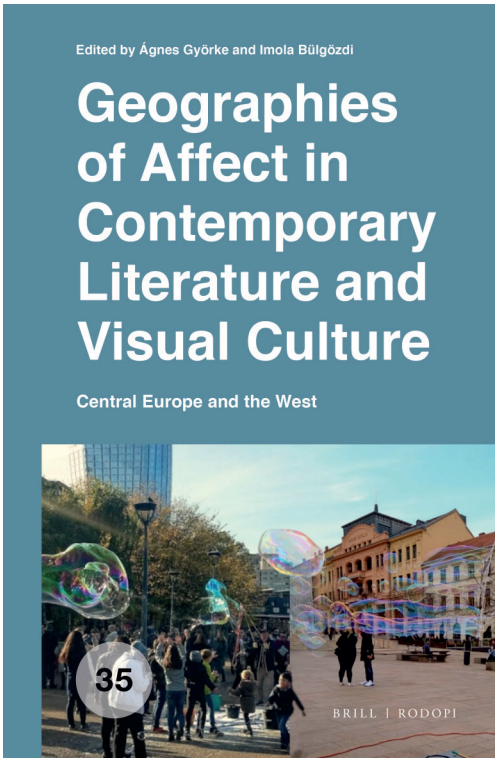
Györke, Á. and Bülgözdi, I. (eds.): Geographies of Affect in Contemporary Literature and Visual Culture: Central Europe and the West. Leiden, Brill, 2020. 234 p.

The concept of 'affect' has influenced research in everyday geography for over two decades. Affect is often used as almost a synonym to emotion in geography, but other times, more-than-representational-theorists in particular (Thrift, N. 2008) emphasise the embodied, spatial, more immediate, even tactile and not-only-human experience that makes affect different from emotion (Davidson, J. *et al.* 2005; Pile, S. 2010; Fabók, M. and Berki M. 2018). However, apart from a few examples, when affect was mentioned (Czirfusz, M. 2014), geographers in Hungary have not engaged with this concept. This is one of the reasons it is particularly exciting to hold this book edited by Györke and Bülgözdi, professors of Literature, English and American Studies and Cultural Studies – hopefully inspiring more geographers too to engage with 'affect' and its relation to space.

Throughout its twelve chapters, this book, a variety of literary and filmic works produced in Central and Eastern Europe and in the Anglophone world are analysed, focusing on the relationship between geographies and affect, while 'translocality' provides with and extra conceptual frame. Drawing on Brickell, K. and Datta, A. (2011), Györke and Bülgözdi chose 'translocality' as an analytical compass to "overcome the blind spots of popular theories of globalization and transnationalism; it 'emerged from a concern over the disembedded understanding of transnational networks'" (p. 23). Moving beyond the elusiveness of nation states and globalisation as well as the dichotomies they often lead to (i.e. core-periphery / East–West discourses), the use of translocality in this volume enabled the analysis to happen on an everyday scale, while also considering geopolitical processes. At the same time, it also enabled contributors to "re-think the significance" of the Central and Eastern European region; "in other words, the volume investigates the significance of localities and subjectivities within the context of global flows" (p. 4).



The book starts with a helpful introduction by the editors, Ágnes Györke and Imola Bülgözdi, that sets the agenda of the book – as summarised above –, followed by 12 chapters structured into 5 sections. Among others, this book features the works of scholars of the University of Debrecen, and it is the result of a collaboration between thirteen scholars, eight of whom have been members of the *Gender, Translocality and the City Research Group*.

In Part 1 *(Edgy Feelings: Translocality, Trauma, and Disengagement)* the contributors focus on pieces that are capable of "surpassing personal emotion and creating a transpersonal affective community" (p. 10). Through the analysis of two contemporary New York novels, Vermeulen, P. highlights the "the power of literary affect to cut across the borders between established constituencies and groups (and even individuals)" (p. 22), and localities. In his analysis of Open City and 10:04 he explains the differences between affect and emotion by highlighting that emotion is more codifiable. Using these two novels he showcases literary strategies that generate unruly affective dynamics, and mobilise unpredictable affects that move beyond personal emotions, through impersonal affect to transpersonal community (Vermeulen, P., Chapter 1, p. 26). In the following chapter, we see a similar process through a theatrical performance based on the memories of Éva Fahidi, a Holocaust survivor, aiding our learning about what it means to performatively create an affect-based community. The act and the observer's affect rely on the uniqueness of a theatre as a context for story-telling – in terms time and space – that is reinforced by piano music and a dancer. "Theatre performances can function as media to stage traumas for a twofold reason. First, trauma can be defined as a kind of memory written into the body [as Assmann 2012 argues], and second, trauma, just like the space itself, is

of an extra-temporal nature" (Takács, M., Chapter 2, p. 36). Lisa Robertson's experimental poetry in her volume *Occasional Work and Seven Walks from the Office for Soft Architecture* explores urban space in Vancouver "as resonating with an array of affects that are not owned and are often historical, yet call for change" (Pálinkás, K., Chapter 3, p. 54).

Part 2 *(East-Central Europe as a Translocal Space: Gendering the "Periphery")* has been particularly interesting for me with its gendered analysis of the city and attention to private-public relations from late-state-socialism until contemporary Central and East European urban spaces. The private-public, Budapest-countryside, inside-outside relations, borders and boundaries are the spatial-affective dimensions of the documentary and feature-films analysed by the authors in this section. Kalmár's chapter focuses on non-hegemonic masculinities in – what he names – retreat films: *Taxidermia* (2006), *Delta* (2008), and *Land of Storms* (2014). In these Hungarian retreat films, where identity politics plays a central role, the disappointed male protagonists return to their home country with "disillusionment about their formal dreams about the urban, hyper-modern lifestyle associated with *the West*" (p. 71). The imagined dichotomous relations are well illustrated in the chapter. The return to the "Othered" Eastern European context means to leave behind a more public sphere associated with masculinity, also leading to a crisis of identity (Kalmár, Gy., Chapter 4). Continuing with the perspective of four women in four movies – *Fagyöngyök* (Mistletoes, 1978), *Családi tűzfészek* (Family Fire-trap, 1979), *Panelkapcsolat* (The Prefab People, 1982), and *Falfúró* (Wall Driller, 1985) –, another genre, named "housing movies", is conceptualised. Győri argues, by drawing on the concept of architectural patriarchy, that contrary to the socialist promise of an equal society, pronatalist policies along with high-rise blocks, in fact, fed into gender inequality. As he writes "the collaboration between the paternalistic and the patriarchal regimes, most evident in the subordination of welfare policies to national economic considerations that privilege male control and ensure female subordination in the home" (Győri, Zs., Chapter 5, p. 95). In *Queer Sex and the City – Affective Places of Queerness in Contemporary Hungarian Cinema*, Feldmann contrasts mainstream depictions of queer spaces – where "*shame*" is the emphasised affect in relation to queer spaces – and more productive, queer historiographic documentaries, in which a sense of belonging is emphasised that leads to a more fulfilled queer spatial experience. The chapter focuses on state-socialist and post-socialist Budapest (Feldmann, F., Chapter 6).

Part 3 *(Translocality, Border Thinking and Restlessness)*, moving away from the Central and East European context, also unfolds affects evoked on the borderlands, this time in the United States and Iran. Translocality is a bodily experience for the migrating protagonists of these chapters who bear traces of local and global histories. The chapter by Bülgözdi unfolds 'fascination' as the main affect that defines translocal experience of the Southern African American migrant arriving to Harlem during the 1920s in the novel by Toni Morrison. As explained contradictory emotions are aroused by this specific urban context that also have a strong identity forming power for the lead character, defined by race, gender, fear and spatial experience (Bülgözdi, I., Chapter 7). In the following chapter, Kőrösi discusses Marjane Satrapi's Persepolis Books. While hard to compare, in the autobiographical graphic novel, the Iranian female protagonist's act of moving to Vienna is also characterised by disappointment in the West and by a struggle with hegemonic masculinity. But unlike the male characters of Chapter 4, Marjane's experience and double critique (of her two homes) – Kőrösi argues – is defined by oppressive patriarchal regimes both in the Islamic state and Western Europe as well as her racialised experience in the later (Kőrösi, M., Chapter 8).

Part 4 *(Translocality and Transgression)* also has a major focus on border-crossing and moving across borders to worlds that often seem more different than they are. Combining surreal with realistic fictions the heroes of these stories blur boundaries through wondering across realms and places, creating alternative meanings of home. Drawn upon an array of critical theorists, geographers, feminists, and litterateur, the chapter by Kérchy draws on the ethos of Alice in wonderland by Lewis Carroll while analysing its contemporary reinterpretation by China Miéville Un Lun Dun ("UnLondon"), placed in the nonsensical mirror version of London, mostly constructed from the trash discarded by Londoners. This ethos is characterised by the recycles and critique of the idea of the "lost little girl." Kérchy also highlights the way wondering and wandering of Alice challenges masculine geographical discourses, arguing that "Alice's journey has nothing to do with the masculine appropriation of space, it lacks a conquistador's colonizing intent, it never aims to reach a final destination, nor does it give account of a teleological development" (Kérchy, A., Chapter 9, p. 167). The next chapter, entitled *Translocations of Desire: Urban Topographies of Love in Chimamanda Adichie's Americanah*, tells a love story of a Nigerian couple, whose blackness, migration, border-crossing, relocation, displacement and home-making result in new spatial and affective experiences (Leetsch, J., Chapter 10).

Part 5 *(Criminal Affects: Crime and the City)* focuses on the classical themes of fear and crime in the city with the analysis of a noir novel and detective series. Both the novel and the series are explained as stories subverting the original, hegemonic approach of the genre having ethnic minority and female characters as their protagonists and by shifting towards a more affective exploration as opposed to the 'masculine ra-

tionality' traditionally associated with the genre. The chapter by Bényei discusses Patrick Neate's novel the *City of Tiny Lights*, where again, an alternative London – this time turned into a war zone – provides the scenery, this time for the investigations of the black British war veteran and private detective. The plot is defined by the relationship between local, urban every day and the geopolitics of colonialism. According to the analysis, these overarching translocal agendas are embedded in the spatial experience of the "main characters, whose affective maps, coloured by guilt, fear, and nostalgia, provide alternative visions of the city" (Bényei, T., Chapter 11, p. 14). The Chapter *Inventing History: Katalin Baráth's Middlebrow Detective Series*, tells a different type of detective story of a female protagonist, Veron Dávid, an accidental detective. Her struggles due to her gender, class, and rural background, while travelling across early 20th century Austro-Hungarian Monarchy, took her on a "quest to carve out a place for herself as a woman and a detective" (Hudácskó, B., Chapter 12, p. 222).

I believe that the volume *Geographies of Affect in Contemporary Literature and Visual Culture: Central Europe and the West* contributes to a better understanding of the very complex concept of 'affect' – and not only for the Central/Eastern European reader, and not only in this specific context. It highlights the role of space in literary and filmic contexts – where it is often subordinated to time –, promoting a richer, more tactile, and more *affective* experience, when consuming these literary and filmic works. I would like to make just one generic critique that is due to the book's emphasis on space and geography. I believe that some of the studies would have benefitted from a further geographical literature. Nevertheless, this book is visibly inspired by, and engages with geographers and space theorists such as Doreen Massey, Henri Lefebvre, Edward Soja, Liz Bondi, Gillian Rose and Rachel Pain and theories such as the production of space and thoughts on the relationship between space and place.

Finally, I would very much recommend this truly interdisciplinary book in particular for all the space theorists and geographers with a hope that it will inspire more researchers in Hungary to incorporate affect and the concept of translocality in their research combining it with geographical scholarly literature, space theories, and empirical methodologies leading to new, interdisciplinary approaches to knowledge production.

Mirjam Sági[1]

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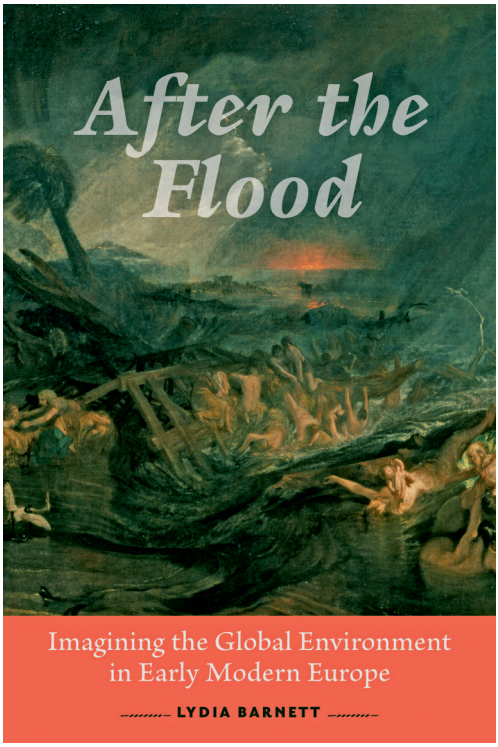
Barnett, L.: After the Flood: Imagining the Global Environment in Early Modern Europe. Baltimore, Johns Hopkins University Press, 2019. 264 p.

After the Flood represents an important contribution in dealing with the long history of human impact on the environment. As the subtitle suggests, the book investigates how the issue of global environment became a scientific and philosophic topic beginning in the European modern age. Barnett moves from contemporary concerns about global warming and environmental degradation as also expressed by Pope Francis' encyclical *Laudato si'* in 2015 to bridge the present debate on the Anthropocene with the reflections regarding the human role in transforming the nature that emerged at the time of the Protestant Reformation and Catholic Counter-Reformation.

The analysis is based on extensive research among printed and archive sources collected in several archives and libraries, particularly in northern Italy. Barnett's discourse focuses specifically on the intellectual discussion of Noah's biblical flood that flourished in the late sixteenth century, a debate that interpreted human sin as the cause of planetarian cataclysm and natural disasters. Her hypothesis is that, well before the large-scale transformations brought about by industrial society, there existed an idea of humanity as a unified body that could act to transform the natural world on the global scale. As occurred in the biblical account, these transformations produced by human agency could be interpreted as a possible threat to the survival of humanity and the world itself. Noah's flood also came to be used as an archetype for explaining European political and religious divisions and conflicts at the time and for imagining the future, salvation, and human redemption from sins. The research focuses specifically on the intellectual contexts of Protestant Britain and Catholic Italy while also investigating the role Switzerland's religious and philosophical *milieu* played as a mediator between northern and southern Europe. Barnett stresses the importance of actors and networks in developing and exchanging ideas about nature, religious disputes, and political claims in relation to the rise of colonial exploration and overseas dominions.



Studying the Universal Deluge was thus part of the effort to reunify Christian Europe by understanding the fragmentation and clashes caused by religious divisions across the continent and, at the same time, by bringing together religion and science as "a way of thinking about unity and division, place and globe, in a world that was both deeply divided and rapidly expanding" (p. 6). This intellectual development was also connected to the effort to spread European civilisation all over the world. Significantly, the introduction presents a very powerful image – drawn from Georg Horn's history of the Universal Deluge of 1666 – that represents the bridge between the post-flood restoration of the world enacted by Noah and the new European world order that was emerging at the beginning of the modern age.

The book begins with an extensive theoretical introduction in which Barnett develops a long-term historical perspective about the awareness of the human impact on the environment, showing that it emerged well before the rise of modern, industrial society. Building on the growing body of literature in the history of science and environmental history and critiquing an environmental determinism perspective, she sustains that, from in the modern age onwards, European intellectuals grappled with the consequences of human agency in transforming the natural landscape: "Clearing forests, draining swamps and fens, and 'improving' arable land were all undertaken with the intention of hastening or forestalling climatic changes that they believed would either promote or interfere with their political, social, and economic goals" (p. 9). Specifically, the author moves beyond a traditional approach in which premodern society with its supposed perception of a

humanity dominated by God's will and the predominance of natural forces is treated as separate from modern secularised society with its recognition of human agency's role in shaping the world of nature.

Of course, Barnett recognises the important differences between early modern perceptions of human/nature interactions and contemporary debates on climate change and environmental degradation connected with anthropic transformation. However, she argues that, beyond the global imaginary built through exploration and field trips, commercial routes, and colonial expansionism, a perception of global catastrophe was also fundamental for establishing a global consciousness in European thought. The Universal Deluge made it possible to think about different races spread across the earth's surface, to imagine a global climate giving rise to the various transformations in the natural landscape, and also to envision a post-diluvian world as "a depopulated wasteland waiting to be restored and reclaimed" (p. 12) that humanity needed to settle and populate through migration.

This debate made possible the circulation and mediation of ideas in a transnational perspective, reinforcing a significant trans-scalar way of thinking that brought different local knowledge into contact with one another and generated different spatial and temporal scales. Moreover, Barnett identifies a connection between early modern concerns about catastrophic floods and global climate issues and present-day reflections on the Anthropocene and climate change: "premodern histories of the planet and people centred on the biblical story of Noah's Flood were premised on several ideas that fell out of fashion in the 19th century but have rightly returned to view in recent decades: the idea that human history must be written in reference to nature's history; that the earth's future should be of equal concern as its past; and that multidisciplinary collaboration is necessary in order to reconstruct the past, understand the present, and discern the future of the human species and the global environment" (p. 18). This premodern perspective also transcended the idea of humanity having a common destiny and uniform collective responsibility, a move paralleled by recent anti-speciest accounts of the Anthropocene asserting that different global populations bear different degrees of responsibility for climate change. Different representations and re-interpretations of Noah's flood, she argues, can in some ways be considered the forerunners of the contemporary imaginary which "derives considerable force from its recollection and reactivation of deep cultural myths about the awesome power of floods to ruin the world as the unintended result of human behaviour – myths that are, it must be noted, not universally shared across the diverse human cultures on the planet and thus not equally compelling everywhere" (p. 19).

In the chapters that follow, Barnett illustrates the complex debates and circulation of ideas that have shaped the modern understanding of the biblical account through time and space.

The first chapter is dedicated to the rise of studies about the Great Deluge in Renaissance northern Italy, starting from Camilla Erculiani's late sixteenth century work in the city of Padua. Erculiani, who was also one of the few female thinkers published at this time, explained the Flood as a consequence of overpopulation and began to interrogate natural-philosophical issues and the biblical account. Barnett also analyses her work in relation to that of other European intellectuals. Chapter 2 is dedicated to the transatlantic networks that developed during the 17th–18th centuries between Spanish catholic colonies and protestant scholars to put the role of colonisation into relationship with studies on the Flood.

The next two chapters are dedicated to philosophical discussion on the Flood in dialogue between England and Switzerland that unfolded until the early eighteenth century. Specifically, Chapter 3 is dedicated to the figures of Thomas Burnet and John Woodward and their claim that humanity might find redemption following the Flood, while Chapter 4 analyses the correspondence between Woodward and the Swiss naturalist Jakob Scheuchzer. Chapter 5, finally, returns to Padua to engage with the figure of naturalist Antonio Vallisneri and his discussion of the theories developed by English and Swiss protestants from a catholic perspective.

One of the book's strong points is its impressive reconstruction of the networks and circulation of ideas that sustained this debate across two centuries. Barnett has also connected these reflections to the present debate on climate change and environmental issues, deconstructing certain preconceptions and shedding light on the history of science and environmental history by tying early modern theories to contemporary assumptions and moving beyond the nineteenth-century idea of a separation between nature and humanity.

Further research could potentially analyse in more depth the connection between the histories and imaginaries produced by these past religious-philosophical accounts and contemporary theoretical debates and methodologies investigating the Anthropocene.

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