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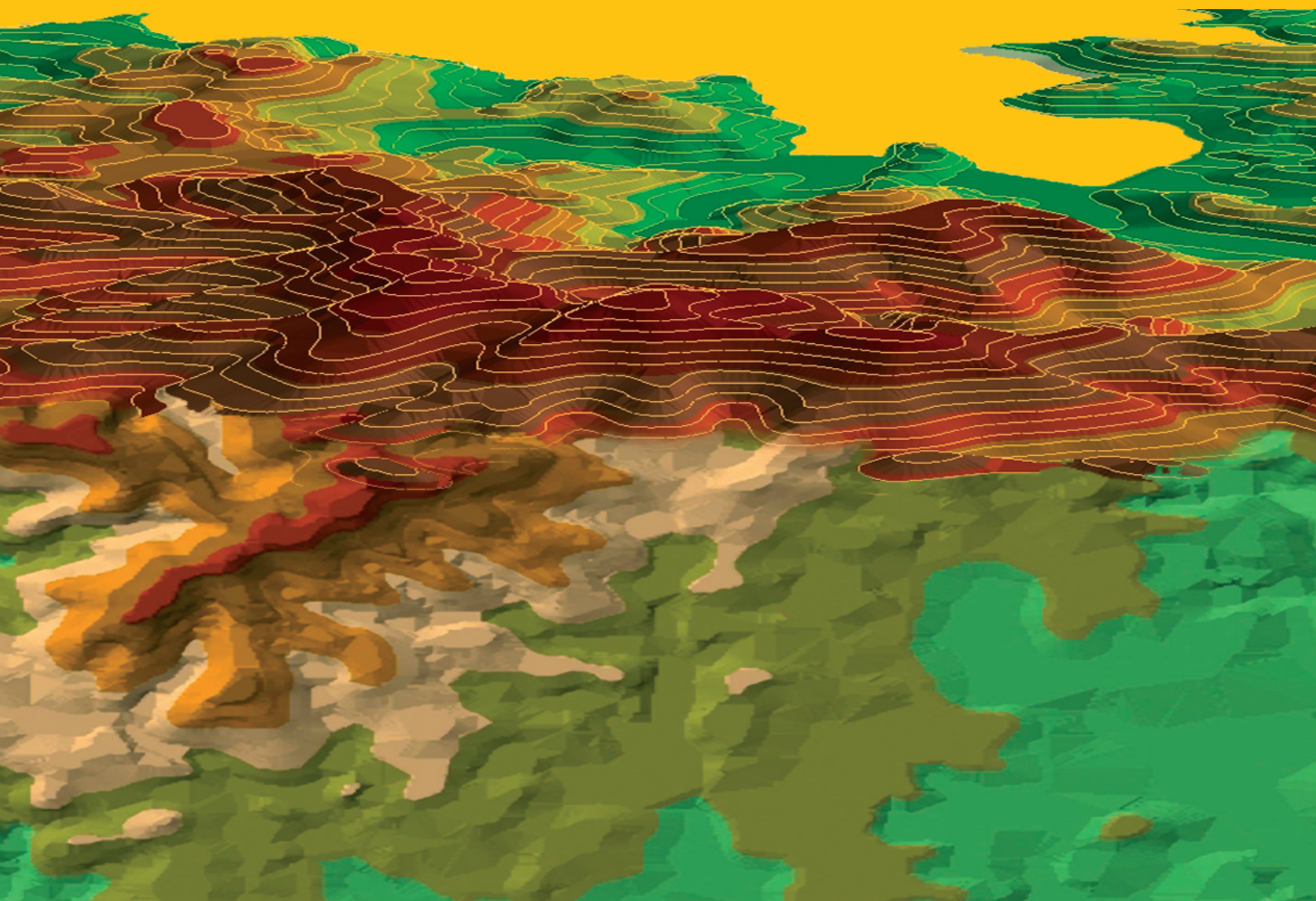

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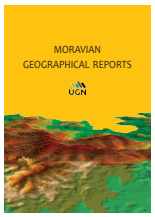

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How should we do the history of geographies during the period of state socialism? Historical period, space and expert knowledge in the post-war Czechoslovakia

Jan DANIEL [a *]

Abstract

A critical reflection on the current state of research into the history of the production of geographical knowledge during the period of state socialism is presented in this report. Using the example of the Czechoslovak administrative reform from 1949, several questionable aspects of current interpretations are identified. In particular, the problematic use of three crucial concepts in the study of the history of geography: time (a politics of memory); space (spatial imaginations); and geographical knowledge. Examples of approaches to each concept are presented, which can overcome the insufficiencies and contribute to a better understanding of the mutual relations between state socialism and the production of geographical knowledge. Research into the history of geography during the period of state socialism is important both to understand the current state of 'post-socialist' national geographies, and to add to the production of an inclusive history of global geography. One necessary condition is, however, to leave the current descriptive and encyclopaedic styles, which are marked with ahistoricism and presentism. In contrast, it is essential that the history of geography during the period of the state socialism become a serious issue, which is analysed through critical and reflexive approaches.

Keywords: *history of the production of geographical knowledge; state socialism; politics of memory; spatial imaginaries; Czechoslovakia*

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1. Introduction

The 'boom' of research in the history of geography is presently emphasised as part of some encyclopaedic overviews summarising the state of the art of international geography (Ferretti, 2021c; van Meeteren and Sidaway, 2020). Livingstone's (1992b) book ´The Geographical Tradition´ is considered the initial impetus of such a boom; it changed dramatically considerations of the history of geography (see e.g. Boyle et al., 2019). Considering the significance of this book, its reception can be utilised to evaluate the present state of the history of geography in various geographical traditions. The fact that is often in dispute from the view of international geography that the book focuses on Western/Northern geographical tradition (see e.g. Craggs, 2019; Sidaway, 1997, on the author's self-reflection see e.g. Hoyler et al., 2002; Livingstone, 2019). This criticism is part of a broader and long-lasting dispute on the dominant position of the Western/Northern, primarily Anglo-American geographical tradition within international geography (see e.g. Minca, 2000; Müller, 2021; Timár, 2004).

An attempt to correct this state, that is to overcome its thematic and spatial exclusiveness, can be marked as one of the significant features of the present study of the history of geography (Ferretti, 2019a, 2019b, 2021b; Keighren, 2018). The study of the geographical traditions of the Global South is emphasised mostly in this context (see e.g. Craggs and Neate, 2020; Ferretti, 2021a). Opinions have been heard recently, however, that it would be appropriate to focus also on what Müller (2020) calls Global East (generally, see e.g. Ferenčuhová, 2016; Jehlička et al., 2020; Jehlička, 2021).

If the example of some geographical tradition was used to question the unequal position of non-Anglo-American geographies within international geographies, it can also be used to question the development of the study of the history of geography in individual national and linguistic traditions. Ferretti (2019c) refers to the different and in some respects contradictory reception of Livingstone's (1992b) book in Italian-, French-, Spanish- and Portuguese-speaking geographical traditions. Such differences demonstrate that study of the history of geography follows different aims

[a] Department of Geography, Faculty of Science, Palacký University Olomouc, Czech Republic (*corresponding author: J. Daniel, e-mail: *jan.daniel@upol.cz*)

in different national traditions, and that it has different significance and impact. It can be stated from this point of view that the response to Livingstone's book was almost null in Czech geography. This is caused, among other factors, by the fact that the history of geography is of marginal concern in Czech geography.

In this article, I discuss the current state of research into the history of the production of geographical knowledge in Czechoslovakia during the period of state socialism. My aim, however, is not to write a 'classic' country report. Considering the almost complete absence of this type of research in Czech geography, such an attempt would lack a deeper sense. Therefore, I chose a different approach. Instead, I will use a case study, which is work on the current interpretations of the mutual relationships between geographical knowledge production and the regional reform of 1949.

I had three main reasons to select this case study. The first one is the fact that the attention of Czech (Czechoslovak) geography was traditionally dedicated to practical definitions of regions and their potential use within the territorial administrative reforms (for an overview: see Klapka, 2019). This feature is why the practical application of the concept of region can be considered a good starting point for a broader project of the critical and reflexive history of the production of Czech (Czechoslovak) geographical knowledge. Secondly, in the current dominant geographical narrative, the definition of regions within the 1949 reform is considered an example of good geographical knowledge which had been misused by the socialist regime. Therefore, the selected example will allow me to demonstrate how the narratives of the mutual relationship between geographical knowledge and state socialism are produced. The third reason is the fact that the 1949 regional reform is updated repeatedly in current public discourse. Thus, the comparison of selected aspects of the geographical and non-geographical narratives allows a researcher to demonstrate how the present geographical interpretation is situated firmly in the broader social and historical context.

The main aim of this article is to critically reflect on current interpretations of the mutual relationship between geographical knowledge and the 1949 administrative reform. Given the scope of the topic, I will primarily focus on the issues of how current interpretations utilise three significant concepts of the study of the history of geography:

i. Time (a politics of memory);
ii. Space (spatial imaginations); and
iii. Geographical knowledge.

This approach will allow me to identify the troublesome points which relate to current interpretations and, based on my own research (Daniel, 2016, 2017), to suggest procedures which could overcome these troublesome points.

Although this article only deals with one partial case study, I will attempt some 'generalisation' in the conclusions about the significance of the three above-mentioned concepts in any research of the history of geography, i.e. I will try to propose approaches which in my opinion should contribute to the production of critical and more reflexive history of geography in the period of state socialism.

Although the title was inspired by Stuart Elden's (2013) paraphrase of the famous text by Ian Hacking (1991), regarding my approach, I was inspired by some texts by Trevor Barnes (see e.g. Barnes, 2001, 2003, 2014). Like Barnes, my aim is not to present a new coherent and internally consistent approach replacing the existing interpretations. I rather try to present briefly some selected alternative approaches and outline their potential to contribute to a better understanding of the mutual and complex interconnections of politics, space and geographical knowledge production during state socialism.

This article is part of a more extensive project focused on a critical history of the production of geographical knowledge in the period of state socialism. A corpus of relevant texts and archival materials is systematically processed. The texts which were published after 1989 dealing, at least marginally, with the 1949 administrative reform, were selected from this corpus to be used for the purposes of this article. The texts were selected in the next steps which do not only provide a factual description of the basic characteristics of the reform but strive to interpret the described facts. These texts were then processed using the Atlas.ti program. My primary focus in the analysis itself was on utilising the three above-mentioned concepts, i.e. time, space and knowledge in the interpretation of the 1949 administrative reform. I also tried to 'map' the boundaries of the sayable. For this reason, I have included non-geographic interpretations in my analysis to point out that – despite their contradictory conclusions – they are based on the same assumptions, i.e. that they are situated within the same discursive limits that are delineated by the current dominant politics of memory.

First, I will briefly assess the current state of the history of geography as a sub-discipline of Czech geography. This concise section serves as a starting point for the case study itself, focused on current interpretations of the mutual relations between geographical knowledge and the 1949 regional reform. I will present the current interpretations of the 1949 regional reform following a summary of the basic facts of the reform. Then, I will investigate the question of how the current interpretations apply the concepts of time, space and geographical knowledge. Primarily, I try to point out some questionable issues related to the current applications of these concepts. Based on this critical reflection and my own research, I will attempt to outline the possible ways of surpassing these questionable issues in the following part. In the conclusions, I will try to propose "general" approaches which, in the context of applications of these concepts, might contribute to the development of a critical and more reflexive research on the history of geography in the period of state socialism.

2. History of Czech(oslovak) geography

Two fundamental features are typical for research on the history of geography in the Czech environment. The first significant feature is the fact the history of geography is hardly practised. At present, only Jiří Martínek devotes his time to this issue in the long term and with consistency. The main subject of Martínek's interest is factually rich biographical studies of geographers (see especially Martínek, 2017; from several shorter texts, see e.g. Martínek, 2010, 2012) and encyclopaedias of Czech geographers and travellers (Martínek et al., 2006; Martínek, 2008; Martínek and Martínek, 1998). Apart from biographical texts, he is also the author of several brief overview histories of geographical institutions, which are primarily based on lists of important persons, texts, and conferences (see e.g. Jeleček et al., 2006; Jeleček and Martínek, 2007; Martínek, 2014).

The second feature follows from the character of the above-mentioned works, and it can be described as focusing on description and factuality without attempts at placing

them in a wider context and theoretical framework (for the explicit claim allegiance to theorisation, see Martínek, 2017, p. 8). My ambivalent evaluation of Martínek's approach is based on this statement. On the one hand, I truly appreciate Martínek's erudition and long-term donkey work and systemic archival work, which brings much very interesting and detailed information about the history of geography (see e.g. Martínek, 2010). On the other hand, this traditional approach is associated with questions of a more general nature about the significance and position of the history of geography within 'contemporary' geography.

Encyclopaedism may be one of the reasons why the history of geography plays only a complementary or marginal role in the contemporary Czech geographical community (cf. Livingstone, 1992a). The information from the history of the field is considered interesting, but at the same time not relevant for current geographical knowledge production. For this reason, the history of geography is given more attention only in the context of commemoration acts in the case of famous anniversaries, or in lessons where the introductory courses introduce new students to the Czech geographical canon and the famous and rich history of the field.

In my, opinion research into the Czech history of geography need not only be a source of 'outdated' historical curiosities but may also make a relevant and active contribution to current geographical debates (see e.g. Barnes, 2014; Driver, 2013). To achieve this difficult goal, however, it would be appropriate to extend the current unproblematic and primarily commemorative and canonical view (Keighren et al., 2012) of the history of the field, with approaches that emphasise the critical study of history, and which will be associated with more precise theorisation and conceptualisation of the researched topics.

Although it will be critical in some respects of the state of study of the Czech history of geography in the following text, and I will base my criticism on the concepts applied in international/Anglo-American geography, I do not follow the modernisation approach as characterised by Ulrich Best (2009). With respect to that approach, it is not my aim to point out that Czech geography is backward and must be modernised by assuming the developed Western approaches. In contrast, I consider this idea of the backwardness of Czech geography to be one of several reasons having led to the current situation.

After the end of the socialist regime, a transition narrative associated with the idea that the Czech (Czechoslovak) task is to catch up with the West became an extended and fixed part of Czech (Czechoslovak) geography (Ferenčuhová, 2012; Ouředníček, 2017). A schematic and negative representation of the period of state socialism arose within this narrative as an unnatural external deformation, which is the main reason for this backwardness, both in the case of geography and in the case of society. This situation led to the fact that one of the main topics of Czech geography was 'the post-totalitarian transformation', which was referred to as 'the rectifying transformation' (Hampl et al., 2007, p. 479). Given this orientation towards the future (catching up with the West) and a clear rejection of previous developments ('mere' developmental distortions), it was considered unnecessary to deal with the developments of geography in the period of state socialism in any way, either critically or reflexively.

Regarding the absence of a deeper theoretical dispute on this issue of Czech geography (as an exception, see Pavlínek, 2003), it is possible to observe that the history of Czech geography is still at least implicitly anchored in the transitological narrative and the period of state socialism is considered strange, unnatural, and a temporary deformation of the development of Czech geography (see e.g. Jeleček, 2004). One of the reasons is the previously mentioned fact that the history of geography is marginal in present Czech geography. Following the author's research, it would be appropriate to begin to consider the research of the history of geography in the post-war Czechoslovakia as a serious research topic, which can contribute to self-reflexion of the present state of this discipline and its wider significance in the broader social context.

3. The 1949 regional reform: Current interpretations

3.1 Basic facts on the 1949 regional reform

The territorial administrative reform of 1949, which took place soon after the communist takeover in February 1948, represented a significant transformation in the functioning and territorial distribution of Czechoslovak public administration. From the point of view of functioning, the most fundamental intervention can be described as the centralisation of state power and the abolition of self-government (Illner, 1999). Although at present this step is generally considered to be completely negative, there is no consensus in the evaluation of newly created territorial units (see below).

In terms of territorial delimitation, it represented the end of the so-called 'Austrian' model of territorial administrative distribution, which had been used in the Bohemian lands with certain modifications since the establishment of modern public administration in the mid-19th century. At the regional level, discussed in more detail in this text, historical lands were abolished as territorial administrative units and a regional model of public administration was introduced in their place (Daniel, 2013, see Fig. 1).

Another territorial administrative reform occurred only eleven years later, in 1960. As part of this reform, the regional establishment was left at the regional level, but the model of the so-called medium-sized regions was replaced by the model of large regions (Střída, 1960a, 1960b, 1960c). The last regional reform was carried out after the end of the communist regime in 1989. The questions whether to keep the regional model or to renew lands as territorially administrative units was discussed at the beginning of the 1990s.[1] Finally, the medium-size region was born in 2000 (Yoder, 2003).

3.2 The 'Moravian' and the 'geographical' narrative

The 1949 reform represents a topic in Czech public debate which is still alive. As has been mentioned, the reform dissolved the historic lands as territorial administrative units and replaced them with the regional model, which is still used at present. It is quite regularly revived in the Czech public space for this reason, whether it be the periodically reoccurring debates on (non)efficiency of the regional establishment (see e.g. Babiš, 2017; Český rozhlas, 28.12.2017) or the restoration of historic lands – primarily Moravia – as territorial administrative units (see e.g. iDNES.cz, 11.02.2019).

[1] This debate is mostly linked to the so-called Moravist movement, whose aim was to restore Moravia as a territorial administrative unit (for a basic overview, see e.g. Hloušek 2015).

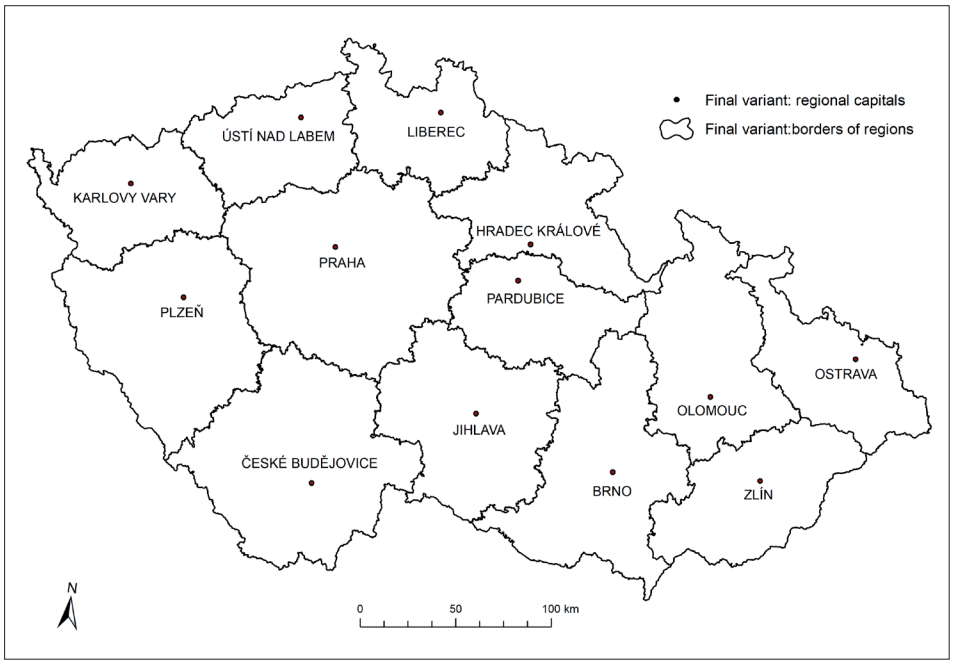

Fig. 1: 1949 Regions, as approved by Regional Act 280/1948
Source: Daniel (2013)

It is possible to identify two main antagonistic interpretations from the few academic texts which attempt at more than this brief factual description (Daniel, 2017, pp. 47–52). The first interpretation is completely negative. The primary reason of such an evaluation is the criticism of the abolition of the historical countries as territorial administrative units and their replacement with regions. Because the abolition of Moravia as a historical land is most often criticised, it is possible to simply label this narrative as 'Moravian'. Probably the most significant representative of this narrative might be historian Jiří Pernes (see e.g. Pernes, 1996, 2010).

On the other hand, the second narrative considers regions to be very well-defined units. This interpretation can be simply marked as 'geographical' regarding its spread in the geographical community. The dominant representation of this relationship can be reconstructed based on texts by Tomáš Burda, who specialises in the historical geography of territorial administrative distribution. He has a similar position in this field as Jiří Martínek in the history of geography: he is the only geographer who has consistently and for a long time dealt with this topic (see e.g. Burda, 2010, 2016). Burda is also the author of map sheets showing the development of administrative distributions in several representative and award-winning atlases (Burda and Jeleček, 2009; Burda and Jílková, 2019), and the official exhibition of the development of territorial administrative distributions, organised by the Ministry of the Interior on the occasion of the centenary of the founding of Czechoslovakia (Ministerstvo vnitra České republiky, 2018). His interpretation can therefore be considered authoritative in geography and, based on my experience, I dare say that it is relatively widespread (see e.g. Ministerstvo vnitra České republiky, 2016).

As has been suggested above, these two interpretations are at directly opposite ends in terms of evaluating the reform. It is possible at the same time, however, which is important considering the focus of this text, to state that their production shows several shared features. If we utilise the dictionary of Livingstone (1992b), then presentism is typical for both narratives. The primary interest is not connected to placing the reform into a broader time-space context of its origin. On the contrary, the reform is interpreted from the view of how the authors evaluated our present time. The result is a simple dichotomous evaluation of good/bad regions following the author's evaluation of the present situation. If the evaluation of the present time is positive, then the 1949 reform is also evaluated positively (see e.g. Burda, 2010), and vice versa (see e.g. iDNES.cz, 11.02.2019). This 'Whig' approach suggests that the narrated story is the only correct one, the only possible one. Therefore, the conclusions are in the form of self-evident truths: i.e. it is impossible to dispute them or to present arguments to support them (for this style of narration see e.g. Burda, 2014, p. 106; Pernes, 1996, p. 179). It is important from the view of the study of the history of Geography that moral judgements used in both narratives relate to the production of spatial and historical imaginaries which predetermine what is good and what is bad.

3.3 The politics of memory I: From the communist coup…

At first sight, the issue of setting the reform in a timeframe seems relatively simple and straightforward. The opposite is true, however. The reason, from the author´s perspective, is the fact that both interpretations create historical imaginaries that can be placed in a broader stream of the politics of memory (Bernhard and Kubik, 2014). This politics of memory was formed in public discourse gradually after 1989 and its core is 'dealing with the communist past', i.e. the evaluation of the period of the communist regime (1948 to 1989) and its influence on the current development of Czech society (see e.g. Kopeček, 2013, 2021).

The 1949 regional reform originated soon after the communist coup of February 1948. This fact is essential for both described interpretations. February 1948 as a significant neuralgic point of Czechoslovak political history, became the key prism through which this reform is viewed. The interpretation of the degree of influence of

February 1948 – more generally the degree of influence of (communist) politics – on various aspects of the reform has a significant impact on value judgements of the reform.

The relationship with February 1948 within the 'Moravian' narrative is described in a clear, simple, and unambiguous manner. The reform is thus considered a direct consequence of the communist coup:

> 'February 1948 gave the Communists a free hand: in order to successfully cripple Czechoslovakia, they had to destroy Moravia and Silesia as an independent administrative and self-governing unit…' (Pernes, 1996, p. 174).

This interpretation shows it as a purely political act connected with solidifying the power of the new totalitarian regime.

The situation is rather more complicated from the view of the 'geographical' narrative. Only a very small number of texts were written after 1989 that would deal more explicitly with the history of the Czech (Czechoslovak) geography in the second half of the 20th century (Jeleček, 2004; Jeleček et al., 2006; Jeleček and Martínek, 2007; Martínek, 2014; Semotanová, 2019). All these texts share two key features with respect to our theme. The first one is the creation of clear limited periods in the development of geography, where the individual milestones of the development of the discipline are equated with the significant milestones of political history (especially 1945, 1948 and 1989).

The second one is the evaluation of the development of geography in the period of state socialism. This development is described mostly from the view of the unilateral negative influence of the communist ideology – whatever this term is supposed to mean – on the development of geography (explicitly, see Martínek, 2014, pp. 25–27). In this evaluation, the idea of two separate and completely opposite entities in terms of their values is created, geography on the one hand and communist ideology on the other. This narrative evokes the idea that in the period of state socialism, pure, objective, scientific and apolitical geography was tainted by foreign and unnatural communist ideology. From this point of view, the period of state socialism is a mere deformation or anomaly of the linear development of geography, and after the end of the communist dictatorship, geography could return to its pure, non-ideological form (see e.g. Jeleček, 2004).

Since the regional reform of 1949 is evaluated very positively, 'geographer' interpretations come into conflict with the above-mentioned schematic division into stretches of time of the development of geography, which is based on the use of milestones in political history. The reform took place only after the communist coup, thus, according to this simplistic model of interpretation, it should be evaluated negatively. This discrepancy is resolved in a simple, as well as also a simplistic way. In this interpretation, reform originated before the Second World War, when important geographers, especially Jaromír Korčák, i.e. one of the most important Czech (Czechoslovak) geographers (see e.g. Imre and Novotný, 2016), participated in its preparation (Burda, 2010, 2012, 2014; Burda and Jeleček, 2009). Its implementation was postponed due to the Nazi occupation until the post-war period, and as the result of political developments, it was implemented only after the communist coup (see e.g. Burda, 2010). Therefore, the Communists had hardly any share in this 'good' definition of the regions, as it was based on the 'good', i.e. apolitical, and professional pre-war knowledge. Thus, in the 'geographer' interpretation, this was not a communist reform, but one used/abused by communists (Burda, 2012, p. 35).

3.4 Spatial imaginaries I: From eternal container…

I understand the 'stories and ways of talking about places and spaces that transcend language as embodied performances by people in the material world' (Watkins, 2015, p. 509) as spatial imaginaries. It is possible to state from this point of view that both narratives contain the significant idea that there are natural areal units, which are good, and unnatural ones, which are bad. Using these spatial imaginaries – similarly to time – plays an important part in the moral evaluation of the 1949 regional reform.

The only natural areal unit is Moravia in the case of the 'Moravian' narrative, which is seen as the result of a thousand years of historical development (see e.g. Pernes, 2010). In extreme cases, territorial, legal, or even national continuity is derived from the so-called Great Moravia, a state unit from the early Middle Ages (see e.g. Hoskovec, 2013). According to this interpretation, the natural, and therefore correct, development was disrupted within the framework of the 1949 regional reform. The natural unit was replaced with an artificial political construct. This fact leads to an unequivocal moral rejection of the reform, which can be documented by the explicit statement of Jiří Pernes (1996, p. 179):

> 'On the first of January 1949, Moravia and Silesia really disappeared from the map of Europe after a thousand years of existence and were replaced by a number of non-natural bastardly malformations called regions.'

According to Pernes (1996, 2010), proof of this unnaturalness is the fact that these regions lasted only eleven years and were replaced by other – larger – regions in 1960. Thus, in his opinion, even the communists realised that the created regions 'lacked the preconditions for a meaningful existence' (Pernes, 2010, p. 401). The injustice was not remedied even in democratic conditions, when Moravia was not restored as a territorial administrative unit, according to the supporters of this interpretation. On the contrary, the regional model was 'only' modified, so the current situation is also assessed very negatively (see e.g. iDNES.cz, 11.02.2019).

The 'geographical' interpretation is based on the belief in the existence of a universal and natural linear developmental trajectory of territorial distribution. This belief is based on a somewhat unhistorical and teleological idea that objectively there is only one correct regional distribution of the territory (see Burda, 2014, p. 106). If a reform respected the trajectory of the natural development, it is well defined. According to Burda (2010, 2014), it is possible to utilise the positive evaluation for the regional reform of 1949 and for the current definition of the regions of 2000. This evaluation is based on the visual similarity of the course of regional borders and the fact that both variations contain the same number of regions and the same regional capitals (Burda, 2010). On the contrary, the 'bad' definition is associated with the reform of 1960, which, according to Burda, can be described as a 'kind of developmental disorder' (Burda, 2014, p. 106).

Both narratives then follow from the imagery of a linear development of natural and eternal regions which may be interrupted unnaturally because of wrong political decisions (the 1960 reform in the case of a 'geographical' narrative, the 1949 reform in the case of the 'Moravian' narrative). Such a deformation does not impact the existence of these natural regions, however. It only makes it impossible to utilise them in the administrative structure of a state. Therefore, the change is not irreversible. On the contrary, a correction may occur, as was the case of the 2000 reform

for the supporters of the 'geographical' narrative (see e.g. Burda, 2016, p. 12), or it might still be expected, as is the case of the Moravian narrative (see e.g. Hoskovec, 2013). After a correction, the development is back at its natural developmental trajectory that was neglected because of the deformation and its impact. Thus, regions have the character of stable units which exist independent of the development and social changes. They form a framework for human activities, whether be it good if the framework is respected, or bad if an unnatural deformation occurs.

3.5 Expert knowledge I: From eternal and linear geographical knowledge...

As regards the relation between geographical knowledge and reform, the situation in the 'Moravian' narrative is relatively simple. As has been mentioned above, the reform is primarily interpreted by its supporters as a product of the communist ideology (see e.g. Pernes, 1996).The regional delimitation is considered an act of political licence for this reason, and as such, the role of expert knowledge in regional delimitation is ignored.

The opposite situation prevails in the case of the 'geographical' narrative, where, on the contrary, the use of geographical knowledge is given a fundamental role. As mentioned above, administrative regions are considered a pure product of geographical knowledge that has been abused by the communist regime. Here, I will focus more closely on two aspects of this approach to geographical knowledge. Firstly, on what is considered 'good' geographical knowledge. Then, on the issue of linearity of production and reception of geographical knowledge.

The assessment saying that the 1949 delimitation of regions was 'good', is based on two basic arguments. As has been suggested above, the first one is the similarity to the present regions which are 'well' delimited. For example, Burda (2010, p. 773) states in his assessment of the 1949 reform that the regions were well delimited, and that this fact was confirmed 'after 2000, when the present regional structure basically copies the 1949–1960 delimitation'. As evidence of this 'good' delimitation, the map depicting a similar course of regional borders of 1949 and 200 is repeatedly used (see Burda, 2010, 2014; Burda and Jeleček, 2009: see Fig. 2).

This argument is troublesome for at least two reasons from the point of view of the history of production of geographical knowledge. It simplifies the complex issues of the regional concept only in its material cartographic representation. That is, it does what was in my opinion the most significant feature of post-war geographical knowledge production: it decontextualises and deconceptualises the regional concept (see below). It views the region only as borders delimited on a map. Thus, it ignores theoretical and methodological solutions used in constructing the borders, as well as the time-space context of their origin. If we want to interconnect the study of the history of geographical knowledge and the history of territorial administrative structure, I believe that it is necessary to focus primarily on conceptualisation of the region which was utilised within the reform and not on secondary phenomena, such as the delimitation of boarders.

At the same time, it is not possible to focus only on the resulting reform, but it is necessary to open the 'black box' (Latour, 1987), to put it simply, not to study the result but to focus on the process of origin. Delimiting the final form of regions cannot be seen as a straightforward process (Daniel, 2013). The approved form of regions is created in a process of very complicated negotiations with the participation of several heterogenous participants with often completely opposed interests. From this view, the resulting form of the regions may be considered a 'messy contingency' (Livingstone, 1992b) and not a rational or pure product of geographical and apolitical knowledge.

The second supporting argument in evaluating the 'good' regions is the influence of geographers on their definition. In the case of 'good' regions (1949 and 1960), there is a repeated explicit emphasis on the significant proportion of their delimitation by geographers (Burda, 2010, 2012, 2014). On the other hand, in the case of 'bad' regions (1960), the participation of geographers is not mentioned in the least. There are again two troublesome issues.

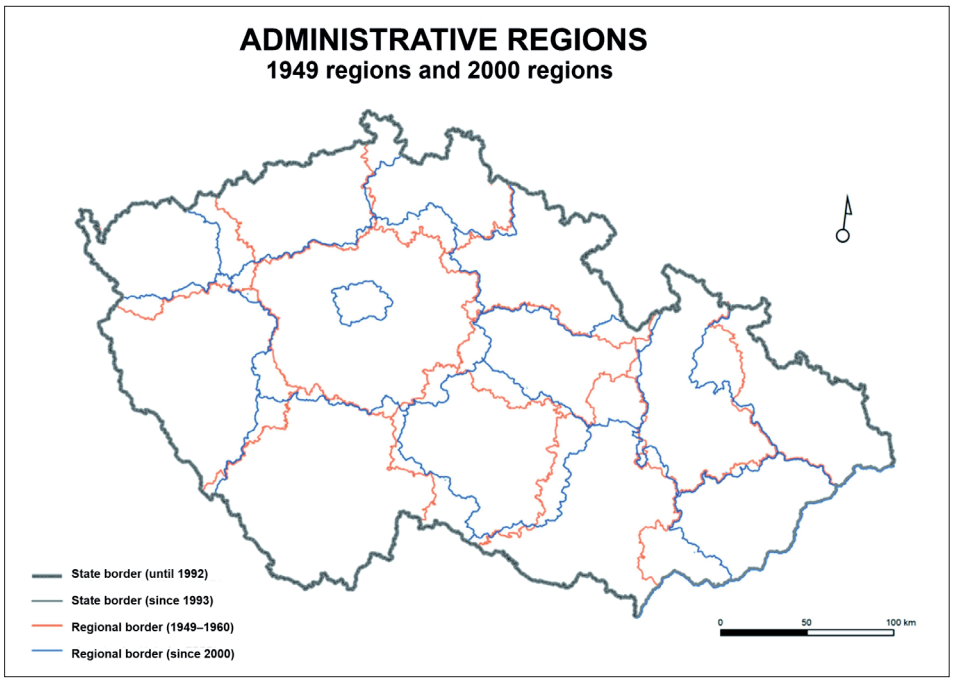

Fig. 2: Comparison of the delimitation of boarders of the 1949 regions and 2000 regions
Source: Burda (2014)

On the one hand, based on the studied materials, I believe that, in fact, the situation was the opposite to that emphasised in the geographical narrative. In the case of the 1949 regions, the influence of geographers was only mediated (see below). On the other hand, the expert 1960 delimitation of regions was fully executed by geographers (see Střída, 1960a, 1960b, 1960c). The second troublesome issue is connected to the character of geographical knowledge and the role of geographers in its 'uncovering'. The applied approach does not consider the changes in geography and considers geographical knowledge as static and permanently valid. It is interconnected in this sense with the above-mentioned spatial imaginaries about the existence of one correct and eternal regional structure. At least implicitly, it evokes the idea of geographers as the only people who can discover the hidden 'truth', embodied in a metaphysical and eternal regional structure that awaits being (re)discovered by geographers. (cf. Barnes, 2003).

The narrative of well-defined 1949 regions is based on the idea of a linear development of geographical knowledge. As has been mentioned, according to the supporters of the 'geographical' narrative, this 'good' definition was created by geographers – primarily Jaromír Korčák – before the war and subsequently used/abused by the communists in the post-war period. In the context of my research, I can repeat that I consider this version of the story of the 1949 reform to be simplistic and ahistorical. I do not make this statement to deny the influence of Korčák's (1934) regionalisation on the production of geographical knowledge in the post-war period. But I do consider the idea of a problem-free linear reception of pre-war knowledge in the post-war period to be simplistic.

The Second World War cannot in any case be considered a mere 'delay' after which the development followed linearly from the pre-war development. On the other hand, post-war development was typical for its attempts at distancing from the previous development (Brenner, 2015), which was related to the project of building a new society and new space (Daniel, 2016, see bellow). Following the author's research, it is necessary to read the reception of Korčák's regionalisation in the post-war period in this context. The experts dealing with the issues of region in the post-war period (1945 to 1949) agreed on the fact that Korčák's regionalisation represents the most significant work in this issue (see e.g. Martin, 1946a; Okrouhlý, 1947b; Šulc, 1946). At the same time, they assessed it strictly in the context of the project of building a new society and space. Regarding the fundamental significance of the planning for this project, Korčák's regionalisation was assessed primarily from the view of its suitability for the purposes of planning, whether positive (Šulc, 1946), or negative (Martin, 1946a; Řípa, 1948).

4. The 1949 regional reform: alternative approaches

4.1 The politics of memory II: …to building a new society

I would like to draw attention to two questionable issues of the current evaluation of the mutual relation of geographical knowledge and the 1949 regional reform from the viewpoint of temporality. Firstly, to complicate the idea of a linear development and its temporary deformations caused by the turns in political history (see below). Secondly, to complicate the time frame of the reform and its relation to February 1948. From the view of the focus of my interest, i.e. the mutual relation between the reform and geographical knowledge, the key period is neither the period after February 1948, as supposed in the first approach, not the pre-war period, as the second approach emphasises.

On the contrary, based on the studied sources, I can determine that from the author´s perspective it is necessary to focus the primary attention on the period 1945 to 1949. The reason is the fact that the expert proposal of regionalisation – the so-called ÚRO (Ústřední rada odborů: Central Council of Trade Unions) regionalisation – which was used to finalise the regional delimitations originated in 1946 in the context of the preparations of the two-year economic plan (Martin, 1946b; also see Daniel, 2016). If we are interested in the relationship between the regional reform and geographical knowledge, then in my opinion it is necessary to analyse how the concept of the region was conceptualised at the time of this expert proposal (for more details, see Daniel, 2017).

Furthermore – and above all – based on situating regionalisation in the contemporary space-time context, it is appropriate not to view the regional reform as a one-off act. On the contrary, I consider it more expedient to interpret it as an integral part of a larger project of state space transformation (Brenner and Elden, 2009), which was connected to the transformation of Czechoslovak society after the Second World War (see below). The ÚRO regionalisation arose for the purposes of the two-year plan and its aim was to delimit the regions which could be used for the purposes of regional planning (Okrouhlý, 1947a, 1947b, 1947c). Planning had a fundamental significance in the post-war times. It was considered a tool which would help to achieve the creation of a new and better socialist society (see e.g. Frejka, 1946). The ÚRO regionalisation was thus seen as an active tool of the creation of a new society. The unity between the planning and administrative regions was achieved using this regionalisation as a foundation for the final delimitation of regions within the 1949 reform, which was considered an important step in building the new society (see e.g. Martin, 1946b; Okrouhlý, 1947b).

The project of transformation of the society and space was not launched by February 1948 but had begun immediately after the end of World War II and continued even after the communist coup (Daniel, 2017). I do not mean to challenge the significance of the communist coup in the resulting form of the reform by this statement. This influence is indisputable and had a significant impact on the functioning of public administration. My intention is rather to expand our understanding of what is labelled as 'political' in the context of the 1949 reform. In my opinion, it is desirable to consider the very delimitation of regions as a political project that was to be used for a targetted transformation of the society and space. Thus, the regional reform was not only to end the old order connected with the then model (dissolution of lands) and functioning (dissolution of self-government and introduction of centralisation) of the territorial administrative structure, it was also supposed to contribute actively to the creation of the new space and new society using regional planning.

4.2 Spatial imaginaries II: …to politics of space

From my perspective, it would be appropriate to look beyond the idea of space as a static container which creates a passive stage of human history in the study of the mutual relation between politics, space and the geographical knowledge in post-war Czechoslovakia. On the contrary, I find it useful to begin to see space (and the region) as an active factor that is evolving and mutually interacting with the society.

Lefebvre's concept of state space (Lefebvre, 2009b, see also Brenner et al., 2003; Brenner and Elden, 2009; Elden, 2004) may seem to be one of the appropriate tools to analyse the mutual relation between space and society. This approach understands the state as 'dynamically evolving spatial entities that continually mould and reshape the geographies of the very social relations they aspire to regulate, control, and/or restructure' (Brenner et al., 2003, p. 11). Thus, the state is not only passively located in space, but it also represents one of the important tools in its attempts at controlling the social relationships (Brenner, 1997). From this point of view, the delimitation of regions can be considered part of a broader project of the politics of space (Lefebvre, 2009a), the aim of which was to transform the state space and create a new – socialist – society (for more details see Daniel, 2017).

Thus, a space in the post-war period did not represent 'a passive stage', but in contrast, it played an active part in the project of the transformation of the society. It may be stated in simple terms that the transformation of space was seen as a necessary condition for a successful transformation of the society. On the discourse level, the transformation of the state space followed from the notion that the current, i.e. the 'wrong', 'unjust' and 'chaotic' space often labelled as the detrimental heritage of capitalism, had to be replaced with the new, i.e. the 'good', 'just' and 'completely rational' socialist space (Daniel, 2017). Planning was assigned the key role in this process, like the attempts at transforming society. This fact had a significant impact on the conceptualisation of regions. A region in the post-war era was assessed only through the limited views of regional planning. A 'good' region was only that which would conform to the contemporary opinions of planning purposes (Okrouhlý, 1948; see also Daniel, 2017).

These facts are in my opinion important for considering the history of geographical knowledge in the period of state socialism. Expert knowledge played an irreplaceable and vital role. Experts produced the representation of the correct space subsequently applied in political practice. This statement is not supposed, however, to evoke the idea that the originally apolitical knowledge was subsequently abused to achieve political aims. In contrast, it is beneficial to understand the process itself of production of such a kind of expert knowledge as a political project.

Another issue I would like to question here is the simplifying evaluation whether the administrative regions are delimited 'well' or 'wrongly'. It may be said that there is no ideal administrative delimitation which could earn a positive evaluation from all the interested actors, and which would maintain its 'goodness' for eternity. It always depends on who, when, for what reason and what purposes are assessed in the given administrative regions.

From the perspective of geographical knowledge, it is important to assume that each regional administrative division is anchored in the dominant politics of space which was applied at the time of its formation. If we accept this assumption, we can avoid simplifying and ahistorical assessments. A fitting example is the question why quite shortly after the 1949 reform, the new 1960 reform was executed. The 1960 reform is not evidence of the fact that the 1949 regions were wrong as is proclaimed in the case of the Moravian narrative (Pernes, 1996). And the view of the 'geographical' narrative which considers the 1960 reform an act of replacing the 'good' non-communist regions with the 'wrong' communist regions is just as simplifying.

Based on the studied sources, I dare claim that the time closeness of both reforms was caused by a significant change in the politics of space. The 1949 reform resulted from the politics of space which was applied approximately between the end of the war and the turn of the 1940s and 1950s (Daniel, 2016). The emphasis within this politics of space was on the equalisation of economic conditions in the whole country (see e.g. Okrouhlý, 1948). Expert regionalisation, which became expert foundation for the 1949 regional division, was created and evaluated for this purpose (Okrouhlý, 1947a, 1947b, 1947c). In contrast, the 1960 regions resulted from the politics of space, which was formed, following a brief interlude of the Stalinist industrialisation, in the mid-1950s. This politics built upon completely different assumptions and was significantly impacted by the Soviet concept of economic rayons (Žůrek, 1956). Its aim was to form complex and efficient economic regions. The construction of regionalisation, which became the model for the 1960 regional division, was submitted to this aim (Střída, 1960a).

4.3 Expert knowledge II: …to materialisation of knowledge

In terms of understanding the production and reception of geographical knowledge in post-war Czechoslovakia, it is, following the author's research, necessary to focus in more detail on the issue of materialisation of geographical knowledge. The region of the post-war period was conceptualised as a fully practical tool of regional planning. Therefore, the regional concept was often simplified and used primarily in its materialised form, i.e. as a map where lines depicted the borders of the delimited regions. I believe, with respect to this fact, that it is appropriate not to perceive the concept of a region only in the traditional way, i.e. in the abstract and conceptual sense, but also to emphasise the material artefacts of regional visualisation and representation.

For this reason, it may be useful to apply the relation approaches connected with the so-called material turn in geography for the purposes of study of the history of post-war Czechoslovak geography (c.f. Anderson and Wylie, 2009), whether be it the actor-network theory (ANT) or assemblage thinking. I do not try to accomplish a more detailed analysis in this article. I will only attempt at outlining the application of these relational approaches and how they may help us understand better the complex process of the reception of pre-war geographical knowledge in post-war Czechoslovakia.

ANT – among others – emphasises the significance of the material objects in producing expert knowledge (Latour, 1986, 1987, 1999). Material objects, such as maps, books, data, machinery, etc. serve as an immutable mobile (Latour, 1987; see also Law and Mol, 2001) and may pass from one set of time-space coordinates through to others, hence they can be utilised in the production of knowledge outside of the time-space coordinates of their origin. This motion is, however, connected with the translation process during which a new network is enacted (Latour, 1987; Law, 2006, 2009). Although the change may not be visible at first sight, as stated by Law (2006, p. 144), the translation "also implies betrayal…it is both about making equivalent, and about shifting".

Although it looked visually the same in the map representation, Korčák's regionalisation in 1934 is not the same as Korčák's regionalisation in 1946. For Korčák (1933, 1934, 1936), the region was primarily a theoretical concept following from his theory of nation (Korčák, 1931). The application of regionalisation itself for the purposes

of planning contradicted his theoretical principles. Korčák (1934, p. 422) understood region deterministically as a natural area created during a thousand-year development and he himself stood unequivocally against teleological understanding of 'region' as used for planning purposes in inter-war USSR.

Furthermore, the main aim, which was in the post-war period completely practical, was to create appropriate planning regions. Therefore, all theoretical assumptions, that were fundamental for Korčák, were side-lined and all the attention was devoted only to the 'practical' aspects of his concept, i.e. most of all the cartographic representation of delimited regions or their (in)appropriate size (see e.g. Martin, 1946a; Řípa, 1948, see also Fig. 3). We can identify the above-mentioned 'betrayal', which occurred during the translation of Korčák's regionalisation to the post-war network of production of expert knowledge. The post-war practical turn led to the materialisation of the regional concept. Korčák's theoretical concept was 'de-conceptualised', it was equated with the material cartographic representation of Korčák's regionalisation.

In my opinion, it was this materialisation which allowed the positive reception of Korčák's regionalisation in the post-war period. The reason is the fact that 'de-conceptualisation' and the materialisation connected with it, also led to 'de-contextualisation'. The simplified understanding of a region as 'lines on the map' allowed Korčák's regionalisation to get rid of the context of its origin and to travel freely between various, commonly antagonistic, conceptualisations of the region in various time-space coordinates.

Other approaches, apart from ANT, may be useful in that they could emphasise other aspects of this complex process. In this view, it is possible to mention assemblage thinking (Deleuze and Guattari, 1987), which is also connected in geography with renewed interest in materialism. If I tried above to suggest that ANT might help better understanding of the reception of geographical knowledge in various time-space coordinates, then assemblage thinking may be useful for example in the attempts at making the discrepancy between discursive and non-discursive practices a topic to discuss. One of the key issues which assemblage thinking deals with is the relation between the discursive (form of expression) and non-discursive (form of content) elements. Although 'the expressive dimension always comes first' (Buchanan, 2021, pp. 77–79), Deleuze and Guattari (1987, p. 502) emphasise that the expression does not determine the content; on the contrary, both formalisations remain autonomous.

One of the main features of post-war discourses was the rejection of pre-war development (see e.g. Abrams, 2005; Brenner, 2015). Geography was also considered descriptive in the post-war period, and as such a truly useless discipline for the needs of the project of building the new society and new space (Daniel, 2016, 2017). Despite this fact, the cartographic presentation of Korčák's regionalisation – a product of pre-war (= 'bad') geographical (= 'useless and descriptive') knowledge – was used as one of the sources for an expert proposal of the planning regions (Okrouhlý, 1947b), which were applied as a source for the final 1949 delimitation of regions (Daniel, 2017). This paradox, in my opinion, proves the intricacy and complexity of the production and reception of geographical knowledge in the post-war period.

8. Conclusions

I have used the example of the 1949 regional reform to try to demonstrate the specific issues which are connected with the study of history of the production of geographical knowledge during the period of state socialism. I also attempted at demonstrating the possibilities which might facilitate a better understanding of this specific and complex issue using brief examples. Even though, from the view of the international production I have been acquainted with, I only focused on the Czech (Czechoslovak) context, a similar situation exists in other Central European countries (for more on the approach to Hungarian geography, see Győri and Gyuris, 2013, 2015; Gyuris and Győri, 2013; on a criticism of this approach, see Ginelli, 2018). It is possible to state from this point of view that study of the history of geographical knowledge production in the inter-war period in the Central European countries is still not the subject of serious critical and reflexive research interest.

Fig. 3: Comparison of the delimitation of borders of the regionalisation of ÚRO, Korčák regions and electoral regions Source: Řípa (1948)

The study of the history of geographical knowledge production in the period of state socialism may not serve only as a collection of oddities, but if practised as a mapping of the present (Elden, 2001), it may provide essential information for understanding the current state of national geographies in the region of our interest. If, however, it is supposed to fulfil this purpose, it is necessary to approach the study of history critically, to reject the non-problematic understanding of individual concepts such as space, region, time, and geographical knowledge, and to increase sensitivity towards the used sources.

From the point of view of the issue of time within research on the history of the production of geographical knowledge, it is desirable that the period of state socialism ceases to be regarded as an artificial deformation of the linear development of geographical knowledge, after the end of which there was a return to the natural development trajectory. In other words, it would be appropriate to stop seeing the development in the period of state socialism as the period in which the apolitical and purely scientific geography was colonised by a foreign communist ideology (cf. Győri and Gyuris, 2013), but in contrast, to approach it as an integral part of a complicated and mostly non-black-and-white and ambiguous development of the Czech (Czechoslovak) geographical knowledge. Accepting this approach, in the study of history of geographical knowledge, it is necessary not to consider the period of state socialism a unified, internally coherent time unit limited by the clearly defined milestones of the history of politics (1948 and 1989). In contrast, it is vital to approach the issue of continuity and transformation sensitively, both in the relation to the development in the previous and the following periods and within state socialism itself.

A space represents another key geographical concept that is understood within the current study of the history of geographical knowledge in the period of state socialism without questions and no great attention is paid to its conceptualisation. If we want to understand better the complicated and multi-layered relationship between geographical knowledge and state socialism, it is necessary to stop seeing space as a static container and to start perceiving it as one of the fundamental actors of the described stories. Attributing a meaning and recognising the active role of space in the project of building a new socialist society is important from the view of researching the history of geography in the period of state socialism for at least two reasons. Firstly, it will show the significance of geographical knowledge, which had a great impact on the production and transformation of state space, both on the discourse and material level. It is possible to place geographical knowledge from this point of view in the wider context of expert knowledge, which earned quite a large importance within the project of building a socialist society and within socialist governance (on the concept of so-called technocratic socialism, see e.g. Sommer, 2019). Secondly, this fact is important from the view of assessment of the mutual relationship between politics and geographical knowledge. Geographical knowledge was not apolitical. In contrast, it was closely connected to politics through the wider project of the production and transformation of space.

The third important question I focused on from the view of approaching the history of geographical knowledge in the period of state socialism is the conceptualisation of knowledge itself. It is in my opinion necessary to repeatedly reject the unquestionable understanding of the production, circulation, and reception of knowledge as a simple linear process in which knowledge is discovered and subsequently spread through time-space unchanged. In contrast, following the author's research, it is necessary to approach the process of production, circulation and reception of geographical knowledge with appropriate sensitivity and an effort to uncover various levels of this complicated multi-layered process. In this regard, it is appropriate – as I tried to point out in the reception of pre-war knowledge – not to understand geographical knowledge in a traditional way, i.e. only in an abstract and conceptual sense, but to emphasise wider social and material practices.

I believe that a more sensitive conceptualisation of the above-discussed concepts in the study of the production of geographical knowledge may contribute to rethinking the study of the history of geography in the period of state socialism. At the same time, it is necessary to state that my position is modest and not offensive to different opinions. I strive to contribute to the history of geography to become a more inclusive space of open and reflexive discussion (Keighren, 2018). If I appear to be critical to some conclusions of my colleagues, it does not mean that I assert my approaches as the only correct ones. It should not be the aim of this discussion to replace one dominant approach with another one, as dominant. As Livingstone (2019, p. 462) emphasises, 'living traditions – as opposed to moribund ones – are dialogical rather than doctrinaire'.

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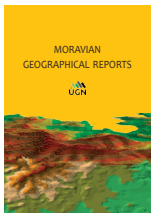

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Spatial regularities in Internet performance at a local scale: The case of Poland

Krzysztof JANC [a]*, Dariusz ILNICKI [a], Wojciech JURKOWSKI [a]

Abstract:

At present the digital divide has started to be considered not so much in the context of Internet access itself or the skills of Internet users, but in terms of Internet performance. The COVID-19 pandemic has revealed that faster Internet made it easier to adapt to the new reality. But not all areas can benefit from good Internet connection. Therefore, the aim of this study is to identify spatial regularities in Internet performance on a local scale. This study is based on a set of data generated by Internet users, collected using the publicly available Ookla Speedtest measurement tool. The information about Internet speed and latency obtained in this way shows the actual Internet speed experienced. The analyses have indicated significant characteristics of the spatial differentiation of Internet performance. First, in the case of the Internet, the core-periphery dimension is not universal and obvious, as regional systems are strongly marked. Second, perceiving the digital divide mainly through the prism of Internet access is an insufficient approach.

Keywords: *Internet performance, digital divide, local scale, Poland*

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1. Introduction

At present, access to digital technologies, particularly the Internet, has become a key factor in local development (Kolko, 2012), contributing to the reduction of poverty (Mora-Rivera and García-Mora, 2021) and, thus, enabling many people to become involved in social life. As with any other resource, however, it is not equally available to everyone. In the context of uneven access to the Internet, the key problem is a digital divide, which can be considered on many levels, including the spatial one (Warf, 2019; Reddick et al., 2020).

The Internet has been evolving along with its growing popularity. This concerns both how it is used (for example, methods of access) and its practical applications (Blank and Dutton, 2014). These changes are observed in the spatial aspects of the Internet. As emphasised by Salemnik et al. (2017), a lack of access to the Internet or poor-quality access (low technical parameters) exclude some communities and social groups from full participation in the modern information society. In geographical terms, they are most often residents of rural areas, particularly those located far away from development cores – large cities and metropolises. Thus, the issue of unequal access to the Internet is important when creating the foundations for regional and national development policies. For such measures to be effective, local differences must be identified in detail and the relationship between metropolises (development cores) and their surroundings and peripheral areas must be defined.

Changes taking place in the use of digital technologies and their impact on the economy and society are defined in various ways, for example as digital transformation and digitalisation (Soto-Acosta, 2020; Rijswijk et al., 2021). Regardless of the terminological approach, all research on the functioning of the Internet emphasises that it has become a ubiquitous and inseparable component of social, economic, and political life. What is more, the COVID-19 pandemic has shown the scale of society's dependence on access to a well-functioning Internet. Changes in the functioning of the public and private sectors as well as the general population's everyday life (for example, Ozil and Arun, 2020), remote education (introduced in most countries of the world) (Nicola et al., 2020), increases in online shopping, and the universal adoption of work-at-home technologies (Barnes, 2020), have clearly accelerated the growth of the Internet's importance, which was already observed for years (Hu, 2020; Soto-Acosta, 2020).

The Internet, along with related technologies, has ceased to be a convenience and has become an essential tool for everyday functioning. Hence, as Sun (2020) notes, the digital

[a] Institute of Geography and Regional Development, Faculty of Earth Sciences and Environmental Management, University of Wrocław, Wrocław, Poland (*corresponding author: K. Janc, e-mail: *krzysztof.janc@uwr.edu.pl*)

divide has become a digital chasm during the pandemic. Moreover, the digital divide has started to be considered not so much in the context of Internet access itself or the skills of Internet users, but in terms of Internet performance. This is pointed out by Lai and Widmar (2020), who emphasise the increased importance of Internet performance (particularly speed) during the forced isolation due to the COVID-19 pandemic. A faster Internet has made it easier to adapt to the need to stay at home, enabling effective access to both education (for example, Cullinan et al., 2021) and work, as well as entertainment and live-streaming forms of socialisation such as weddings, funerals, and religious services (Sun, 2020).

The aim of this study is to identify spatial regularities in Internet performance on a local scale. Internet speed (download and upload) and latency are treated as the defining characteristics of Internet performance; they testify to the quality of Internet access. The reference point for analysing the research results is the relations between metropolises, which are treated as cores, and their surroundings, with particular emphasis on rural areas. This approach makes it possible to refer to one of the key dimensions of the digital divide. The research area is Poland, and the research period is 2020. The analysis is based on data about Internet performance collected in local administrative units (LAUs). For the purposes of this study, we assume that spatial differentiation in the characteristics of Internet performance is one aspect of the digital divide. Poland offers interesting possibilities for analysing the spatial aspects of the digital divide. Poland is one of the few countries in the European Union with a well-developed and balanced pattern of structure and the most polycentric pattern of development; there are significant development disparities between the largest urban centres, taken together with their immediate vicinities, and peripheral areas (Czapiewski and Janc, 2010).

This study is based on a data set generated by Internet users, collected using the publicly available Ookla Speedtest measurement tool. Using this tool, the authors have obtained information about the actual speeds[1] in the areas, rather than those declared by service providers or determined during one-off tests. Importantly, the procedure and conclusions resulting from the research process can be transferred and replicated on any spatial scale and in any spatial context. A large, homogeneous set of data that allows comparisons on a global scale is the key asset of this study. Identification of the ways this data set might be explored, as well as its information potential in the context of spatial analysis, is an important contribution to current research on the digital divide. Moreover, it should be noted that there is a research gap which takes the form of insufficient knowledge about Internet performance at the local scale. In the context of the changes (observed and potential) caused by the COVID-19 pandemic – for example in terms of work and education, spending free time and staying in forced isolation – recognising local scale Internet performance is becoming one of the priorities in the spatial approach to the subject.

Therefore, the novelty of this study consists primarily in identifying and defining the spatial differentiation of Internet performance at a local scale for the entire country. At present, the scholarly literature contains analyses that address the issue of Internet speed; however, in the context of the digital divide, discussion must be developed around the spatial aspects of this phenomenon. This is essential, because in our formulation, Internet performance is treated as being associated with Internet access, but also as having significant impacts on the benefits derived from that access. This sort of approach is essential when considering the perspectives for combatting the exclusion of certain areas, particularly in the context of challenges associated with the pandemic and other crises, as well as the acceleration of digitalisation.

2. A digital divide: different approaches from the spatial perspective

Society, facilities, and infrastructure are becoming more and more dependent on information technologies, regardless of the spatial (urban or rural) context (Streitz, 2018). It is indisputable that Internet infrastructure, particularly broadband, is necessary for business development and general economic development (for example, Magnusson and Hermelin, 2019; Tranos, 2013). From a spatial perspective, an important benefit arising from the use of digital technologies is the reduction of information asymmetry (Jeffcoat et al., 2012) – that is, equalisation of opportunities for the functioning of entities and communities regardless of location and physical access to information sources. Therefore, it is among those factors that eliminate locational discrimination, which affects many areas, primarily peripherally located (mainly rural) areas in relation to the centres of economic and social development. Importantly, villages benefit from the Internet more than cities because of their greater distance (as compared to cities) to alternative locations offering specific goods and services (Williams et al., 2016).

The literature on the subject clearly emphasises that the emergence of new technologies (including the Internet) and their adaptation and use are usually associated with cities. Cities provide the requisite conditions for their functioning and development – a high concentration of individual users and business entities (for example, Kitchin, 2015), the urban lifestyle associated with dependence on the latest technologies (Poncet and Ripert, 2007) and, thus, a greater tendency to absorb them. Although issues and problems in rural areas differ from those in cities (because of differences in economic and social structure), all Internet-based solutions have the same potential impact on development, regardless of location (Cowie et al., 2020). It is important to recognise that, in rural areas, however, the quality of Internet services often hinders attempts at taking advantage of opportunities offered by the Internet. Internet performance is not the only issue involved here: rural residents have less choice of Internet service providers and often pay higher prices for lower quality services (Sanders and Scanlon, 2021).

From a strictly geographical perspective, Graham (2011) separates digital divide into material and virtual exclusion. The former refers to the separation of people from access to digital space, the latter is connected to the blocking or hindrance of movement within digital space. It should also relate to invisible inequalities: the lack of visibility of some social groups and areas in digital space (Ferreira et al., 2021). As noted by Graham and Dittus (2022),

[1] The term "actual speed" should be understood as the speed experienced by users. This need not match the values offered by Internet service providers. Depending on hardware and impediments related to building structure, a user may experience lower connection speeds.

exclusion from content creation (participation) is to a large degree dependent on access to and cost of broadband. The issue of digital divide is closely connected with the geography of participation (Graham et al, 2015). The geography of participation analyses how individual communities are involved in the creation of digital content, primarily via posts on social media, or on services that take advantage of collective work (activities) to create content that is then used (or can be used) by all users of the Internet.

Since the beginning of the Internet, analyses of unequal access to it in various spatial systems have been carried out: between regions and countries and between rural and urban areas (for example, Gorman and Malecki, 2000; Grubesic and O'Kelly, 2002; Whitacre and Mills, 2007; Stephens and Poorthuis, 2015). But as Internet access becomes increasingly universal, other factors are coming to determine who enjoys the full benefits of the Internet and who is excluded from the digital realm. Beyond access, what is important is how the Internet is used and by what kind of users (Brandtzæg et al., 2011). Hence, over time, scholars began considering the role played by the range of skills and knowledge needed for appropriate and effective Internet usage. Hargittai (2002) and introduced the concept of the second-level digital divide, which analyses one's level of Internet skills, particularly the ability to search for information. This is quite a significant extension of the concept of digital divide, as the mere fact of access cannot be treated as a synonym for using the Internet (DiMaggio and Hargittai, 2001).

The term 'third-level digital divide' has also been used in the literature. It refers to differences in benefits obtained from using the Internet (van Deursen and Helsper, 2015). Van Dijk (2005) systematises these different approaches and presents four levels of access to new technologies: motivation to use new technologies; physical access (access to a computer, access to the Internet); skills (strategic, informational, operational); and usage (different ways of using the Internet). Another approach to digital divide is related to the development of mobile technologies that enable the use of the Internet (such as tablets and smartphones). We can see the formation of a so-called 'next-generation user'. This is a user who uses several devices to connect to the Internet, often 'on the move' and from multiple locations (Blank and Dutton, 2014; Lee et al., 2015).

The digital divide is associated with access to the Internet or, in a broader sense, digital technologies, skills, motivations and sociocultural preferences that translate into different ways of using them (Selwyn et al., 2005; Courtois and Verdegem, 2016; van Deursen and van Dijk, 2014). The digital divide is identified with social exclusion, where all members of a community are not able to fully participate in social and economic life. For instance, the way one uses the Internet can affect the socio-economic situation of the user. Better-educated individuals are more likely to use the Internet for the purpose of personal development rather than for entertainment (Taipale, 2013). This leads to an obvious conclusion: the digital divide is tantamount to social exclusion. The digital divide is not a static and homogeneous problem. Its characteristics change in both time (the rate at which new solutions appear and their diffusion) and space. We notice new forms of the digital divide linked to the emergence of new Internet applications, such as the smart divide (Li et al., 2020), related to smart device use.

The emergence of smartphones, other portable devices and the mobile Internet was one of the important stages in the development of the Internet, making it possible to use the Internet from almost any location. The mobile Internet can be treated, on the one hand, as a complement to the fixed version and, on the other hand, as an alternative to the fixed version in situations where individuals lack any other means of accessing the Internet – particularly in developing countries (for example, Srinuan et al., 2011), or in areas with unfavourable conditions for creating a fibre-optic infrastructure (for instance, mountainous areas), which are often also peripheral areas. The determinants of broadband mobile adoption and the characteristics of using this type of Internet in general are the same as in the case of the fixed Internet, with particular emphasis on the location, education, and age of users (Quaglione et al., 2020; Puspitasari and Ishii, 2016). At the same time, as noted by Tsetsi and Rains (2017), those who are less educated and earn less are more dependent on using the Internet only through smartphones.

In many developed countries, the issue of the first-level digital divide (in terms of access) is no longer very important. Most, if not all, residents can use the Internet and have access to it. The key issue, therefore, is to understand not so much broadband penetration as the effects of the broadband quality divide (Philip and Williams, 2019). Due to the increase in the number of potential applications of the Internet, the ability to transmit large volumes of data is important from the perspective of running a business or simply enjoying free time. In this case, symmetry is important – high download and upload speeds. Together with technological progress, new issues come into play, such as the speed of connection (for example, Prieger, 2003; Philip et al., 2015), or the possibility of using devices and the Internet freely outside of the home. Hence, the problem of broadband access, particularly in households, continues to be important. This has been particularly highlighted by the COVID-19 pandemic. Internet performance is, therefore, one aspect of the digital divide. Research in England shows that there are clear spatio-temporal disparities in Internet performance (Riddlesden and Singleton, 2014). Better Internet performance, with the same amount of time spent on the Internet, means an increase in the consumption of news, which translates into more knowledge about events (Lelkes, 2020). According to Lobo et al. (2020), broadband speeds could reduce unemployment, especially in rural areas. This is related, for example, to the development of so-called online labour platforms. They bring benefits, particularly in rural areas, in terms of opportunities to not only perform but also find a job (Braesemann et al., 2020). Kongaut and Bohlin (2017) demonstrate that faster broadband services have a greater impact and stimulate the economic growth of rural areas. Referring to the impact of speed on economic development, Stocker and Whalley (2018) state that it can be seen across the whole economy.

The events related to the transition of a significant part of the population to remote work and learning (due to the COVID-19 pandemic) have particularly shown that Internet speed is important not only in everyday life but also in terms of work and access to services. The most popular online meeting applications (such as Zoom and MS Teams) do not have high requirements for Internet speed – up to 10 Mbps download. In the case of streaming services (such as Netflix), the minimum requirements are also few Mbps, but the highest quality is 25 Mbps. Although these values are not high, if several services are used at the same time or by several users from one connection, the Internet speed must be much higher. Becker et al. (2020) define an Internet speed of 25 Mbps as 'basic' (it supports 1–2 users), 100 Mbps as 'average' (supporting 3–4 users) and 250 Mbps as 'fast'

(supporting 4–5 users). Therefore, according to Dahiya et al. (2021), when paying attention to performance, one should focus not only on download, but also on upload (striving for symmetry) because upstream for home users has increased significantly due to the use of video conferencing applications during the COVID-19 pandemic. The so-called 'online education deserts' have been defined as those whose Internet speeds are below 25 Mbps download and 3 Mbps upload (Rosenboom and Blagg, 2018). For example, in Canada, the 'basic services' required for social and economic participation are 50 Mbps and 10 Mbps, respectively (Hambly and Rajabiun, 2021).

In this way, we should note that Internet performance and concrete access to high-speed Internet should be treated as elements of first level digital divide. What is essential, is that a growth in the scope of Internet use means ever greater dependence of achieved benefits on connection parameters. That dependence clearly corresponds to third-level digital divide. The extraction of benefits from having a fast Internet connection is an essential criterion for subsequent, ongoing social stratification. In this way, Internet performance, being an element of the first level, shapes the third level to a significant degree.

3. Data and methods

3.1 Data: Ookla as a source of information about Internet performance

The basic source used in this study is fixed broadband and mobile (cellular) Internet performance data provided by Ookla[2]. Ookla is a world leader in testing and evaluating Internet speed. The data are collected on a crowdsourced basis, from speed tests conducted by users around the world using stationary and mobile devices, applying the Speedtest tool. Data from crowdsourced speed tests have already been used in geographic studies on a local scale (Riddlesden and Singleton, 2014). Importantly, however, microscale analyses were limited to England. Data from crowdsourced tests (consumers' feedback) are more reliable (if numerous) than those declared by providers, especially in the case of mobile data geographic coverage (Grubesic and Mack, 2015). Hence, the advantage of crowdsourced data over others is that the information about Internet speed and latency obtained in this way shows the actual Internet speed experienced (Lüdering, 2015).

In the context of measurements describing the state of broadband Internet connectivity, speed tests are performance measurements (Bronzino et al., 2021). In the case of Ookla, these are the so-called client-based tests. Ookla is not the only tool for testing Internet speed. It should be emphasised that, depending on the research methods adopted, individual tools can provide diametrically varied results for the same area[3] – nevertheless, Ookla is regarded as the best source of data for evaluating Internet speed (see Bauer et al., 2010). An important limitation is, therefore, the fact that data are obtained based only on the actions of those who conducted the tests. We do not have information about Internet speed from most Internet users, nor do we know about the conditions of the tests conducted (for example, hardware, operating system and so on). Potential data bias is also connected with the fact that we do not know the reason why tests were performed, nor the specific demographic and social attributes of the user population performing the tests. As noted by Paul et al. (2021), tests are usually performed in very specific situations (for example after setting up a new device or arriving at a new location). Aside from these limitations, we assume that with an adequately large number of tests attributed to the analysed spatial units, data are reliable and a representative indicator of general Internet performance.

The data provided by Ookla are spatial and cover the whole world. The values from individual tests have been aggregated to tiles of about 610 × 610 metres (at the equator), marked with a specially dedicated, unique 'quadkey'. The following information can be obtained for each tile: download speed, upload speed, latency, the number of tests conducted, and the devices used to conduct the tests, broken down into quarters of a given year. Data quality depends on the activity and location of users, so the number of tiles is different for each quarter. There are two databases to download: one each for mobile and fixed Internet (based on tests performed for mobile and fixed connections, including Wi-Fi, respectively). In the case of Poland, the average number of tiles for the four quarters of 2020 was 103,567 for fixed Internet and 89,582 for mobile Internet.

3.2 Data aggregation

To obtain the average annual value of download, upload and latency for fixed and mobile connections, a two-stage data aggregation (temporal and spatial) was performed in each research unit.

Temporal aggregation involved calculating the average annual value (for 2020) for individual tiles based on the quarterly values of each parameter:

$$X_T = \frac{1}{n}\sum_{Q=1}^{n} X_Q$$

where: X_T = average annual value of a characteristic in each tile and X_Q = value of a characteristic in a single quarter of a given tile.

Spatial aggregation was performed next. In this study, communes (the smallest administrative unit in Poland) were adopted as the basic research unit. The aggregation of tiles to commune boundaries was performed in ArcGIS Pro, using the "union" tool, which computes a geometric union of the input features. On that basis, all tiles were assigned a commune code – in other words, a new field in the attribute table was added for each tile. This new field was the code of the commune in the territory of which a given tile is located. In cases where commune boundaries passed through a tile (where a tile was located on the territory of more than one commune), the tile was assigned the identifying code of the commune whose territory encompassed the greatest share of the tile in question. After establishing the prescription of tiles to communes, we could proceed to calculating the values of particular measures:

[2] Data are provided based on CC BY-NC-SA 4.0. Speedtest by Ookla Global Fixed and Mobile Network Performance Maps were accessed on 06.05.2021 from https://registry.opendata.aws/speedtest-global-performance. Speedtest® by Ookla® Global Fixed and Mobile Network Performance Maps.

[3] Feamster and Livingood (2020) discuss the technical matters that can impact speed test results. They include, among others, test duration, test server capacity, distance to Wi-Fi Access Point, and client hardware and software.

$$X_U = \frac{1}{n}\sum_{T=1}^{n} X_T$$

where: X_U = average annual value of a characteristic in all tiles within a given unit and X_T = annual value of a characteristic in a single tile within a given unit.

Ultimately, each research unit was assigned the values of six characteristics: the average annual download for fixed and mobile Internet; the average annual upload for fixed and mobile Internet; and the average annual latency for fixed and mobile Internet.

Within urban–rural communes[4], however, cities and rural areas have been separated, making two types of units. On average, 111 tests on 57 devices with mobile connections and 283 tests on 141 devices with fixed connections were carried out in each research unit. In almost 99% of the research units, measurements were taken in each of the quarters, and only in a few cases was no measurement recorded in any of the quarters covered by the analysis.

3.3 Classification method

To achieve the aims of the study, attention was paid to the relationships between the basic parameters characterising Internet performance in spatial terms – through the classification and analysis of research unit rings around the largest cities: province capitals.

We divided the community based on positional measure – in this case, the median was the dividing value. Using this approach, for fixed–mobile Internet pairs for the download, upload and latency variables, the community was divided into four classes and simultaneously evaluated – from I (the best) to IV (the worst) (see Fig. 1). It should be noted that in the case of classes II and III, the one in which the fixed and mobile connection was characterised by a higher value of a given parameter was treated as more important (better)[5]. In the case of the latency parameter, the principle according to which classes were assessed was the inverse of that for download and upload. The lower the latency the better. The order of the classes was determined by the higher value of a given parameter for fixed connections. The base classifications obtained in this way became the starting point for the final classifications[6]. They are a combination of base classifications for individual parameters of the functioning of fixed and mobile Internet performance (download, upload, latency), followed by their comparison with each other. In this way, 16 categories (4 × 4) were created and finally grouped into seven classes. The idea of the applied approach is presented by comparing the basic classifications for download and upload speeds (Fig. 2).

Individual categories were assigned to individual classes based on the number of parameters that were higher (download, upload) or lower (latency) than the median for each Internet connection (fixed, mobile). Thus, the individual categories belonging to each of the seven classes

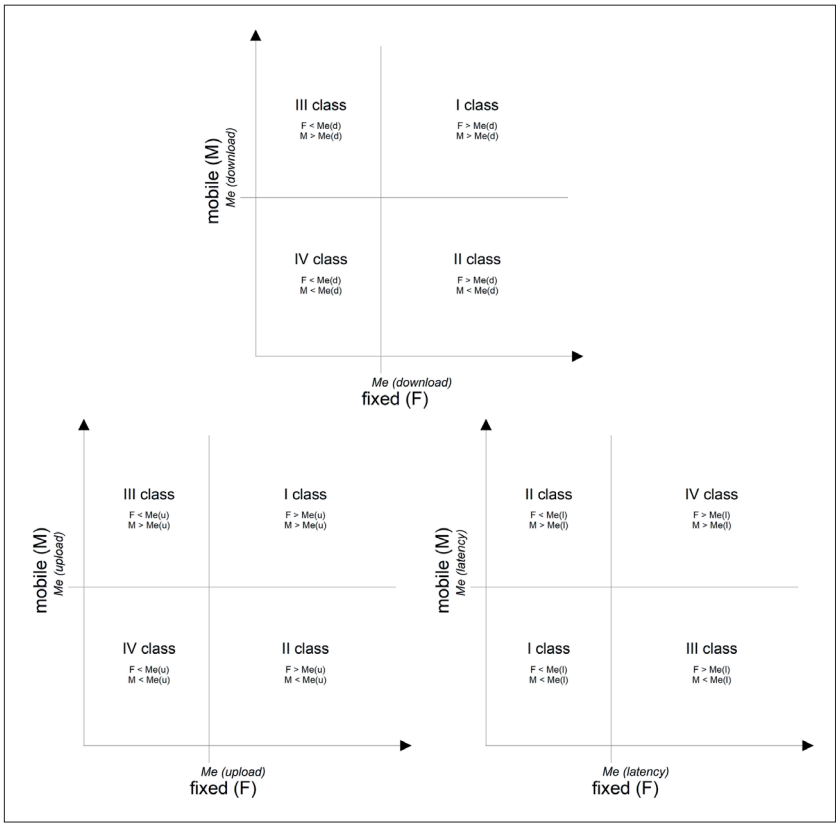

Fig. 1: Schemes of base classifications for individual Internet performance characteristics (download, upload, latency). Source: authors' elaboration

[4] In the smallest administrative unit in Poland, a division into three categories has been adopted: urban communes, rural communes and urban–rural communes.

[5] Higher values are desirable for download and upload, as opposed to latency.

[6] The results show two classifications, namely download–upload and upload–latency. This approach results from the fact that the upload–latency and download–latency classifications in fact show the same spatial differentiation.

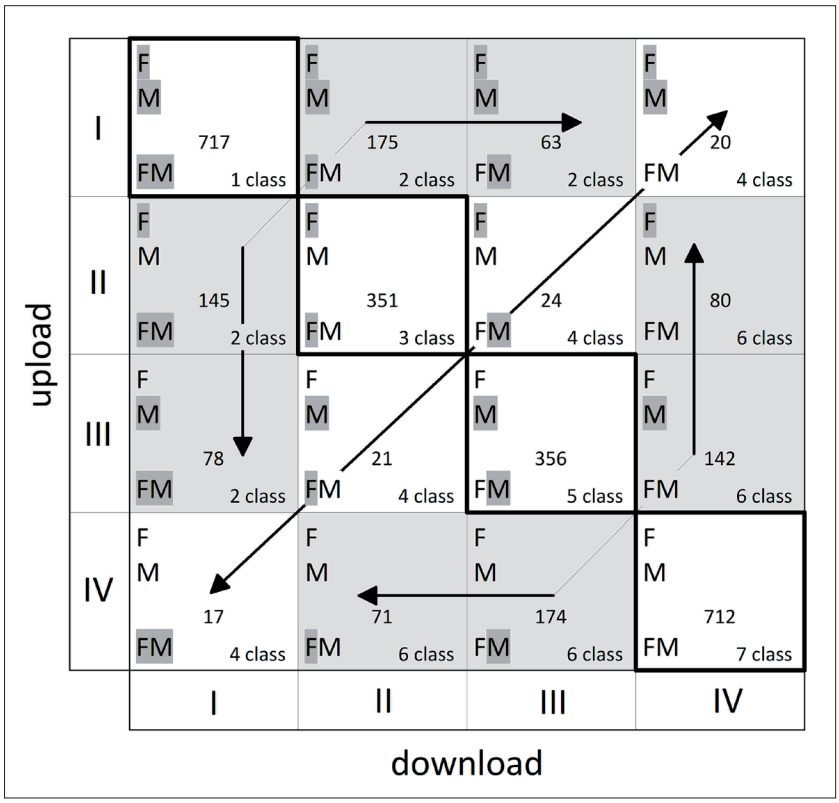

Fig. 2: Scheme of final classifications with categories (16) assigned to individual classes (7) using the example of the download–upload system. Source: authors' elaboration
Legend: (1) the darker grey colour marks those the Internet parameters (upload/download) that are characterised by values above the median for a given type of Internet connection (fixed, mobile) in a given category; (2) those categories that belong to one class are marked with a lighter grey colour in order to make the whole classification easier to understand; (3) the types of Internet connection for the download parameter that are above the median are marked in the lower left corner of each category—as for individual classes of the base classification (see Fig. 1); (4) the types of Internet connection for the upload parameter that are above the median are marked in the upper left corner of each category – as for individual classes of the base classification (see Fig. 1).

are unambiguous (see Fig. 2). For example, in the first class, the values of the Internet performance parameters (upload and download) for fixed and mobile connections are in each case above the median. Similarly, in the 7th class, the values of the Internet performance parameters (upload and download) for fixed and mobile connections are in all cases below the median. Analogously, in the 2nd class, the values of only three parameters are above the median, and in the 6th class, the values of only one of the parameters are above the median. The 3rd, 4th and 5th classes are those that have two Internet performance parameters above the median in each category belonging to these classes. Their order is firstly a consequence of the sequence of categories, from the one that makes up the first class to the last, 7th class. Second, this order results from whether the Internet performance parameters (upload, download) are above the median for fixed or mobile Internet. Thus, for the 3rd class, download and upload were above the median for fixed connection as opposed to the 5th class, where the values above the median related to the mobile Internet. This distinction, based on the consequence resulting from the logical sequence of the categories, is also justified by the fact that both download and upload for fixed Internet are higher than for mobile Internet. The manner and idea by which individual categories were ordered into distinct classes is further presented in tabular format (Tab. 1).

An additional comment is necessary to justify the categorisation in classes III, IV and V (see Tab. 1). In all three of these classes, we are dealing with various combinations of parameters in which the values of two of those parameters are greater than the median. As mentioned above, the upload and download parameter values for the entire grouping of the analysed entities constitute the basic criterion distinguishing one classification from another. When establishing the order of the classes, however, in addition to the number of classes above the median value we also assigned priority based on whether those values are for fixed or mobile connections. Fixed connections were more important, considering their higher upload and download values as compared with mobile connections. Aside from the fact that we are dealing with various combinations of individual parameters that apply to download and upload in differentiated classifications, the order of those classifications can additionally be justified by way of the mean value of all parameters defining a given classification. Such is the case for class III category 6 (see Tab. 1): the average transfer is 45,222 kb/s. For Class IV this value is only 34,908 kb/s. On the other hand, in the last of the classes under discussion (V) average transfer in those of its categories above the median is merely 25,270 kb/s. In this way, such clear differences in Internet speed can serve as the basis for the elaboration of variegated policy aimed at equalising Internet access.

In this study, the issue of the relationship between metropolises and their surroundings was presented through the analysis of data for subsequent rings of units (communes) surrounding the cores, that is, the capital cities of regions. This approach results from identifying

Classes	Categories	Number of Internet performance characteristics above the median	Upload		Download	
			fixed	mobile	fixed	mobile
I	1	4	+	+	+	+
II	2	3		+	+	+
	3		+		+	+
	4		+	+	+	
	5		+	+		+
III	6	2	+		+	
IV	7	2			+	+
	8			+	+	
	9		+			+
	10		+	+		
V	11	2		+		+
VI	12	1			+	
	13					+
	14			+		
	15		+			
VII	16	0				

Tab. 1: Assigning of categories (16) to individual classes (7), as well as indication of how they were assigned: number of Internet performance characteristics above the median. Source: authors' elaboration
Legend: (1) assignment performed according to upload and download Internet performance characteristics; (2) for classes II, IV and VI the number of Internet performance characteristics above the median value is 3, 2, and 1, respectively. In the case of classes II and IV, differences between individual categories is determined by various arrangements or configurations of the Internet performance characteristics. For the categories that are part of class VI only one Internet performance characteristic was above the median value.

the urban–rural digital divide as a metro/non-metro divide (Whitacre et al., 2015). The unit rings have been defined based on the principle of having a common border. Thus, the first ring surrounding the core included those units that adjoined its border (they had a common border at a point or line). The second ring was made up of units that were tangential to the first. The analyses were carried out for 16 (18)[7] cores, as well as for the next three rings, and for the remaining areas (those outside the previously defined rings). The adoption of the core–periphery system as a reference point for the analysis assumed that values in successive rings decrease, and the units in the rings are more like each other than to the units from the remaining rings. This assumption is because the further from the core of a given area, the suburbanisation processes are less and less advanced (for example, Wolny, 2019; Szmytkie, 2020). It is important to determine the distance beyond which development impulses sent from the core are weaker or disappear completely. In the case of Poland, the range of influence of core centres usually covers the first three rings of a research unit around a core. This area is 50–60 kilometres away from its centre – the core. The first ring includes the direct surroundings of the core (Szmytkie, 2019; Ilnicki and Janc, 2021). The second ring, due to the presence of urban units in it, is characterised by a simultaneous strong bond with the core and its immediate surroundings (Ilnicki and Janc, 2021). In the third ring, links between rural areas and the core and towns in the second ring are primarily observed (Fig. 3). Given the fact that the Internet performance characteristics (download, upload, latency) are regional (see classification results), each ring has been limited to the area of a given region or province. This means that when some parts of the research units forming any of the rings were outside the borders of a given region, they were not considered. This is justified because the proximity of some regional capitals would also result in the overlapping of rings and their 'double' classification to the characteristics of individual rings.

4. Results

4.1 General correlations

In July 2021, for mobile Internet, the global average was 55.07 Mbps download and 12.35 Mbps upload speeds, and latency was 37 ms; for fixed broadband, the values were 107.50 Mbps, 58.27 Mbps and 20 ms, respectively. Compared to July 2018, a significant increase in values was observed for each characteristic. Back then, the averages were 22.81 Mbps download and 9.13 Mbps upload speeds for mobile Internet, and for fixed broadband 46.48 Mbps and 22.5 Mbps, respectively (Speedtest Global Index, 2021). Poland was in 45th place in terms of mobile Internet with the following parameters: 55.06 Mbps download and 11.03 Mbps upload

[7] In the case of two provinces (Cuiavian-Pomeranian Province and Lubusz Province), two cities act as the capital, Bydgoszcz/Toruń and Gorzów Wielkopolski/Zielona Góra, respectively. In Poland, a province is the highest-level administrative division (the term "province" is a synonym for "voivodship" – *województwo*).

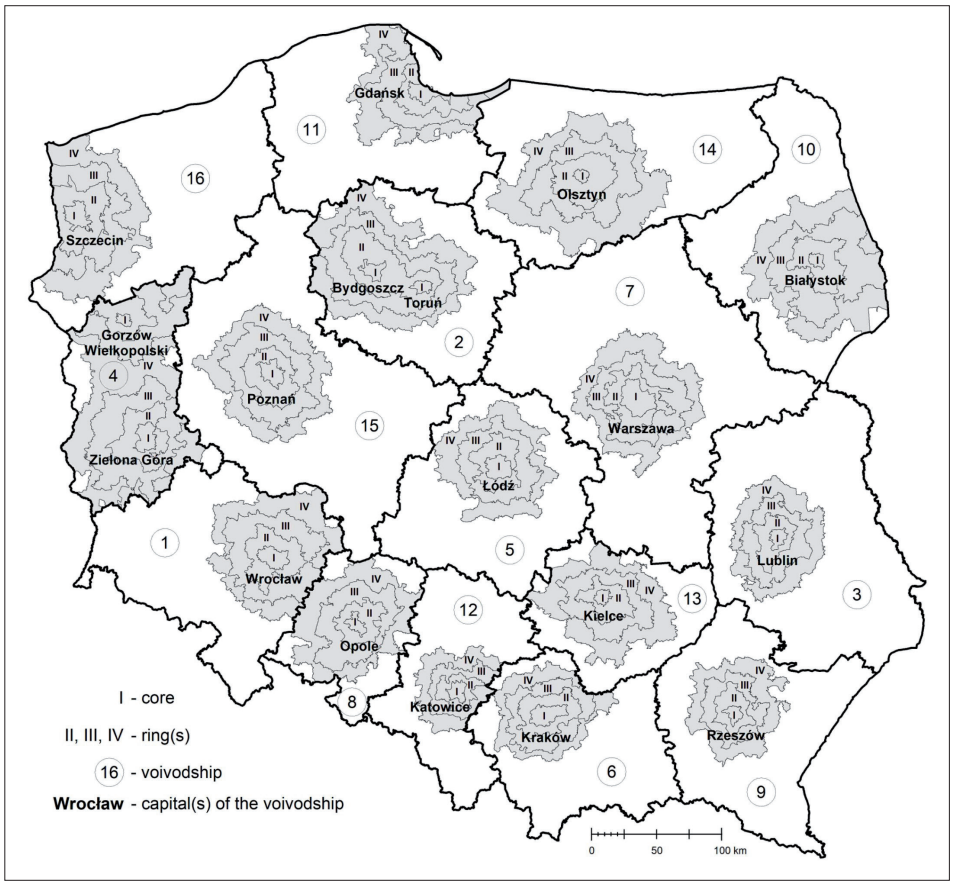

Fig. 3: Research unit cores and rings around them. Source: authors' elaboration
Legend: (1) Lower Silesia Province, (2) Cuiavian-Pomeranian Province, (3) Lublin Province, (4) Lubusz Province, (5) Lodz Province, (6) Lesser Poland Province, (7) Mazovia Province, (8) Opole Province, (9) Subcarpathia Province, (10) Podlasie Province, (11) Pomerania Province, (12) Silesia Province, (13) Świętokrzyskie Province, (14) Warmia-Masuria Province, (15) Greater Poland Province, (16) West Pomerania Province.

speeds, and latency of 32 ms, while for fixed broadband the values were 43.15 Mbps download and 50.57 upload speeds, and latency of 20 ms.

In the case of Poland, there are visible correlations between all three performance measurements (see Fig. 4). This applies to both fixed and mobile Internet connections. There is a strong positive linear correlation between download and upload speeds. Taking account of the entire set of units (n = 3,143), the correlation is higher for fixed than for mobile (Pearson's linear correlation coefficients are 0.795 and 0.722, respectively).

On the other hand, comparing upload and download speeds with latency, the presence or absence of curvilinear correlations can be stated for fixed and mobile Internet. Taking account of the differentiation of units in cities and rural areas, it is noticeable that there is much less latency in cities.

4.2 Spatial differentiation: classification

Reference to a settlement network is crucial to understanding the spatial diversity of issues related to Internet performance. In 2020, the Polish settlement network included 944 cities (Fig. 5). Small cities (up to 20,000 residents) accounted for over 75% of all cities. Sub-regional centres of up to 50,000 residents made up just over 14% of cities. Less than 9% of cities (73) had more than 50,000 residents. There were 14 large cities (over 200,000 residents). The Polish urban settlement network is polycentric in nature, dominated by regional capitals, including the 'big five'[8]. The current shape of the settlement network is a derivative of the intensive suburbanisation processes that began to take place primarily in cities with a population of at least 100,000 residents in the second half of the 1990s. It is important that a positive balance of migration for permanent residence remains between cities and their surroundings (Ilnicki, 2020; Ilnicki and Szczyrba, 2019).

When analysing the spatial differentiation of the basic parameters of Internet performance (Fig. 6), several general regularities should be noted. First, the two classifications presented create a similar pattern of spatial differentiation. Secondly, there is no direct reference to the city-village dimension at the scale of the entire country, and regularities are not subject to regionalisation referring directly to the settlement network (core-periphery systems). Two regions stand out clearly, namely Silesia and Greater Poland, as having the best performance. Also, in the case of some regions, practically all their units, except for cities and possibly their surroundings, can be assigned to the worst performance classes. The core-periphery system is visible in the case of some of the largest centres. Warsaw, with a large suburban area, and most of the regional centres stand out in this regard, as all Internet performance parameters indicate their privileged position. At the other extreme are many rural areas, particularly in the central and north-eastern regions.

[8] Kraków, Poznań, the Tricity metropolitan area (Gdańsk, Gdynia, Sopot), Warszawa, Wrocław.

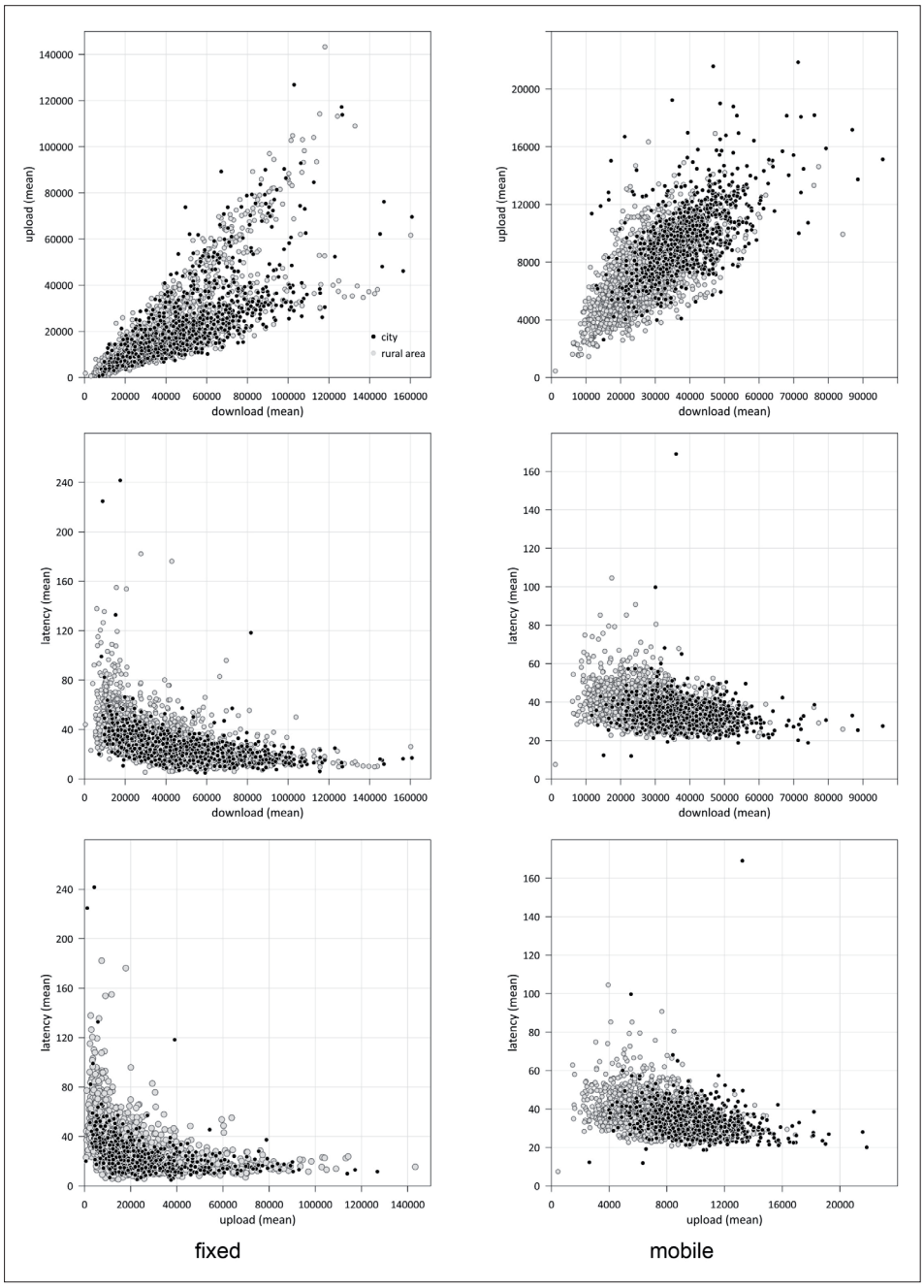

Fig. 4: Correlation between performance measurements (download, upload versus latency) for fixed and mobile Internet by city and rural area. Source: authors' calculations

Thus, the classifications create a picture of the diversity of Internet performance, which consists of two dimensions: regional and core-periphery. The regional dimension, particularly the strong position of the Greater Poland province, is a consequence of individual investment-related activities implemented under the Digital Poland Operational Programme and the operability of the regional Internet providers resulting from their investments. In the case of the Greater Poland province, the Internet provider Inea operates there[9], offering the fastest Internet in Poland. It is one of only a few providers offering access to a fully symmetrical Internet – the same (high) upload and download speeds. Similarly, PPCOM operates in Katowice (Silesia province) and offers symmetrical Internet plans for individual users. It is worth noting that the largest Polish Internet providers – providing services throughout the country or a significant part of it – do not usually offer symmetrical Internet speed.

4.3 Spatial differentiation: the core versus surroundings and the periphery

The observations resulting from the presented classification are confirmed in the concentric ring approach to the analysis for regional centres, which are treated as cores. Comparison of the basic parameters of Internet performance (see Fig. 7) clearly shows the following correlation: the further away from the capital of the region – the core – the less favourable values are for Internet speed and latency. There is a virtually linear, proportional variation in the values of upload and download speeds for both fixed and mobile connections.

[9] This company is based in Poznań and has been operating primarily in the Greater Poland province for over 12 years.

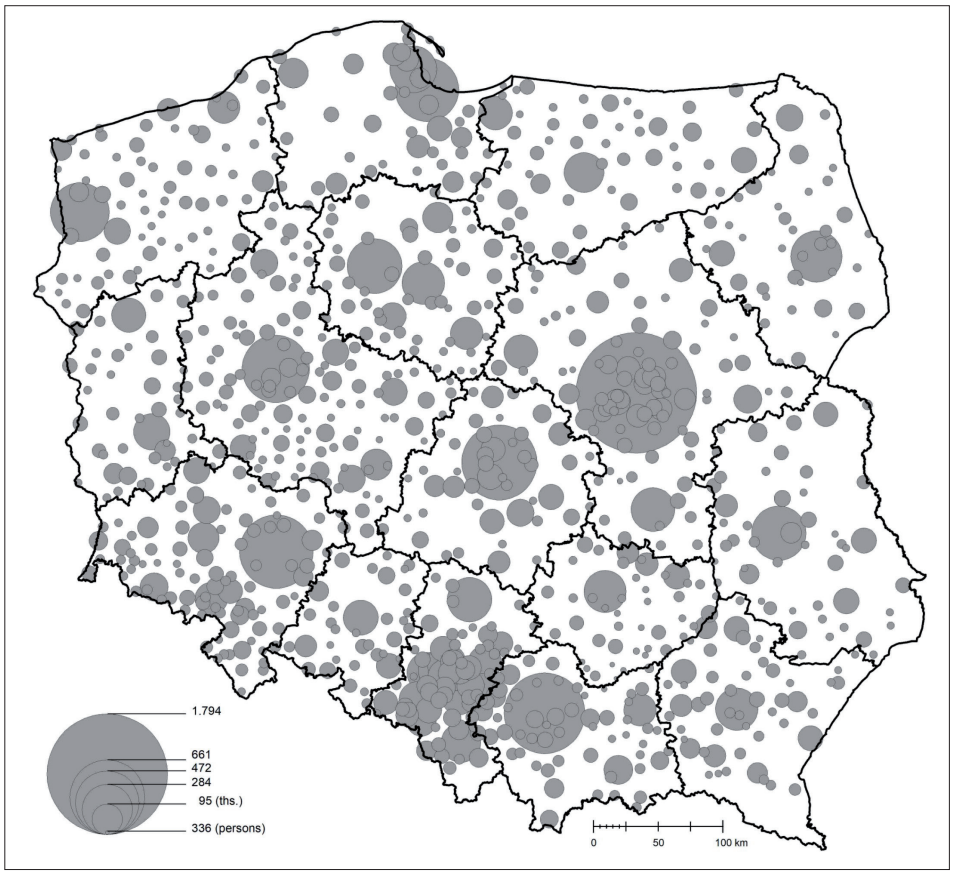

Fig. 5: Population of cities in 2020: square root scaling
Source: authors' research based on Statistics Poland

Moreover, there is also a general regularity: namely, the analysed values decrease from the core outwards through consecutive rings (the highest values – the core, ring I, ring II, ring III – the lowest values).

These observations are confirmed in the juxtaposition of the median values for Internet speed parameters (download, upload, latency) for "core/rings" and "other areas" in general perspective, without their disaggregation into core and surrounding rings (Tab. 2). Firstly, general Internet speed parameters for core and rings overall are better than for other areas. Secondly, in the case of core and subsequent rings, there is a visible decrease in Internet speed values with increasing distance from the core (for which said values are the highest).

Other correlations for rings (download–latency, upload–latency) are not as clearly linear as in the previous case. Nevertheless, there are similar values within individual groups of units (core, rings I–IV). It is also worth paying attention to one more issue, namely, the values of the analysed Internet parameters for other areas relative to

Specification			Core/rings				Other areas
			I	II	III	IV	
Fixed	download	cities	97,865	69,326	53,111	44,908	42,523
		rural areas	–	41,940	29,687	23,497	22,444
	upload	cities	34,166	26,675	20,962	17,542	16,499
		rural areas	–	17,783	12,043	9,972	9,723
	latency	cities	14	16	19	23	24
		rural areas	–	27	32	32	34
Mobile	download	cities	42,545	36,976	38,987	37,456	37,592
		rural areas	–	29,807	27,005	27,390	26,747
	upload	cities	12,369	9,605	9,909	9,531	9,633
		rural areas	–	7,445	7,076	6,987	6,886
	latency	cities	25	30	31	33	34
		rural areas	–	34	35	36	37

Tab. 2. Internet speed for core, rings and other areas in general perspective
Source: authors' calculations

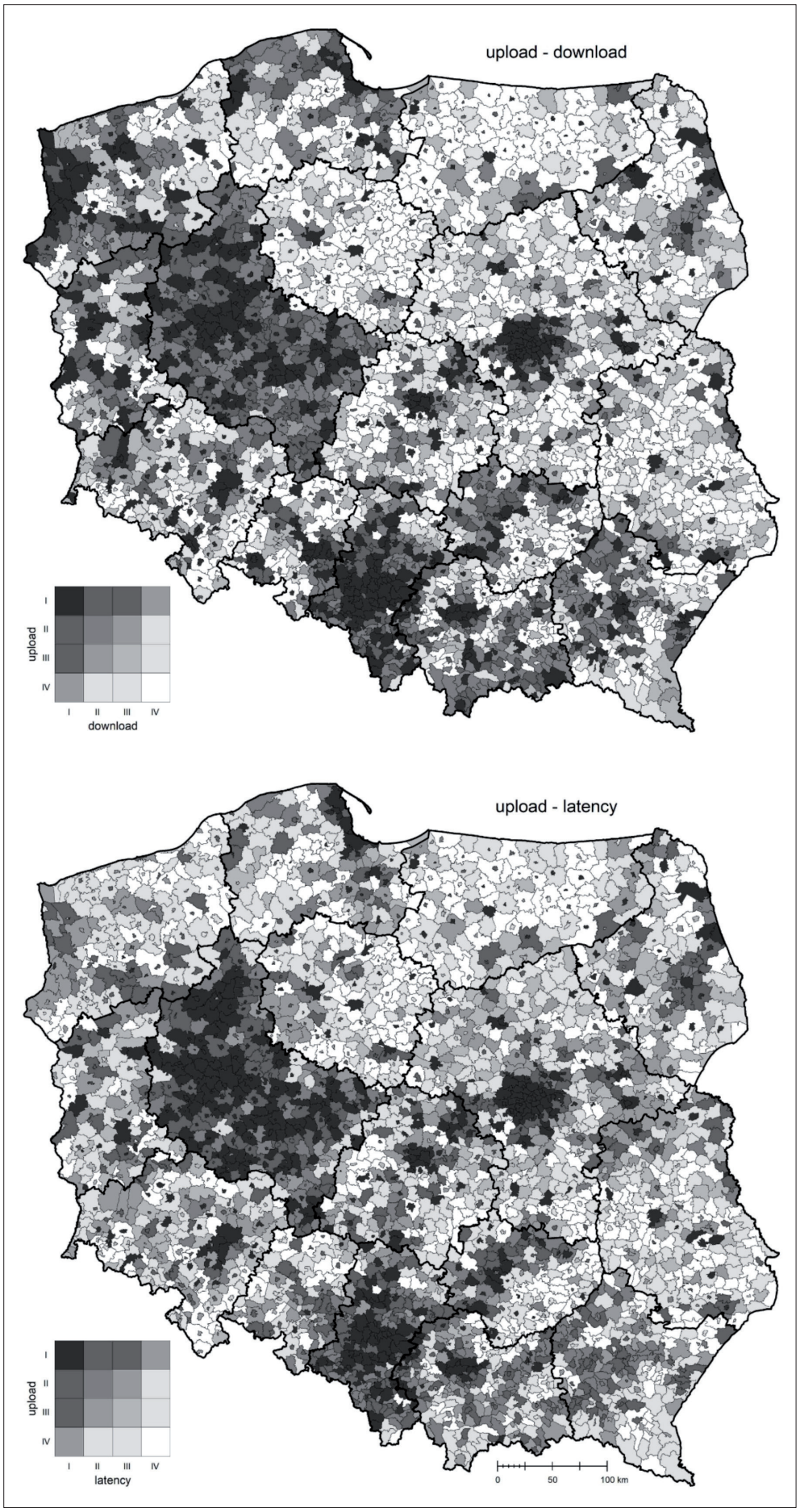

Fig. 6: Final classifications for two sets of performance measurements: download–upload and upload–latency
Source: authors' elaboration

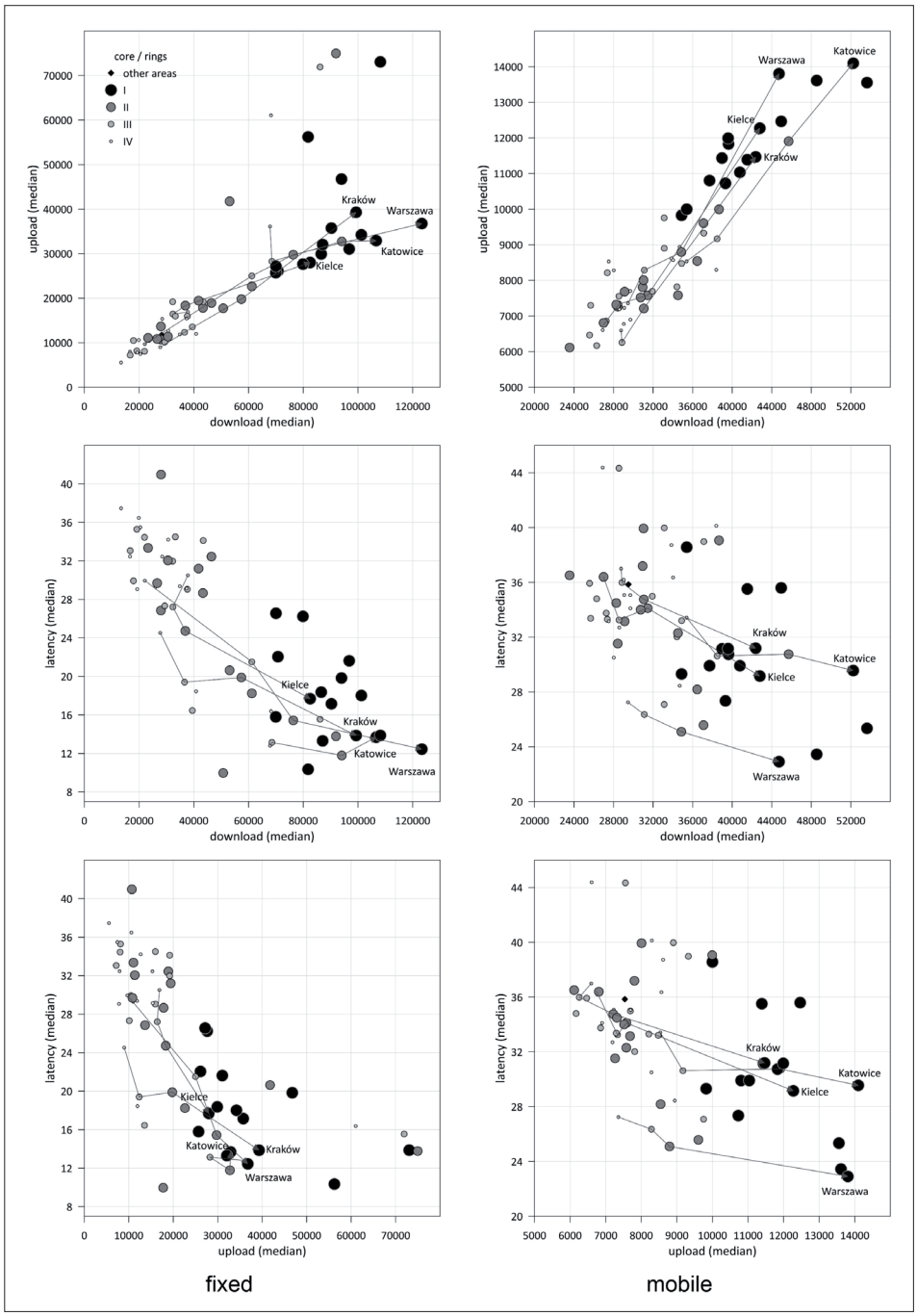

Fig. 7: Correlations between performance measurements (download, upload, latency) for fixed and mobile Internet for the core and the rings of regional centres. Source: authors' elaboration

those describing the cores and subsequent rings. Other areas, to a large extent, have clearly lower and less favourable characteristics of Internet performance than core and ring areas, especially the cores and the first (I) ring units.

5. Discussion and conclusions

Many studies have indicated the presence of the core–periphery system in various aspects of the development and performance of the Internet, particularly in terms of infrastructural differences (for example, Grubesic, 2008; Warf, 2013). Based on the example of Poland, this study shows that, in terms of the Internet performance experienced, we can observe the existence of a system with a 'superimposed' regional dimension. This is important because, from the perspective of creating the foundations for development, it indicates the possibility of reducing unfavourable conditions resulting from the peripheral location of rural areas. Regional Internet providers who make significant investments in infrastructure enable significant reductions in the digital divide. Of course, as is the case with other types of infrastructure that meet basic human needs, the investments are usually carried out to equalise the level of accessibility and improve quality. Thus, it can be assumed that fast, symmetrical Internet will eventually appear in less developed regions. The key question, however, is what consequences will result from the delay in investment. A few months, a year or several years may be a sufficient period for the residents of areas to lose/gain from online work, education, or participation in culture. The formation of differences, magnified by forced isolation, may contribute to the creation of a vicious cycle that deepens the digital divide

(Warren, 2007): namely, people and households with high quality Internet performance will gain a real advantage over those with a poorer level of Internet performance.

In the case of Internet performance, it should be noted that we cannot regard mobile Internet as a perfect substitute for a fixed connection for the residents of remote areas (Srinuan et al., 2012). The analysis carried out for Poland clearly shows that mobile and fixed Internet are closely related. What is important, however, is that, on a larger scale, there is no substitution for a fast connection. Of course, the progress made in the operation of mobile broadband (5G technology) may be the basis for the claim that mobile Internet in rural areas will meet expectations. 5G, however, is currently more common in urban areas; it is being rolled out first in large urban centres. The previous statement can also be applied to another solution enabling high-speed Internet access in rural areas. Satellite Internet, specifically the Starlink service, promises high-speed Internet access regardless of location. This service is currently unavailable in many areas, however, and relatively expensive compared to other types of access. The Internet performance parameters offered, the lack of symmetry and relatively high latency, are also not satisfactory. Bearing in mind the perspective of technological development, improvements and assuming the dissemination of satellite access, however, it is reasonable to ask how and whether it will affect the identified regularities.

As Lüdering (2015) points out, in the case of digital divide analyses, it is crucial not so much to define the participation of people through their level of Internet access, but to define Internet performance (for example, latency and speed). Our study has revealed an important dimension of the digital divide by showing the real speeds of the Internet. Ensuring that measures declared by Internet providers are not used as a source of data in spatial analyses is crucial for understanding the analysed phenomenon. This is particularly important and visible in areas distant from metropolises, where the 'effective bandwidth available to users can diverge significantly from the maximum theoretical "best effort" (up to "X" Mbps) speeds' (Hambly and Rajabiun, 2021, p. 3).

Despite the limitations related to the specificity of data, the analyses presented here have indicated several significant characteristics of spatial differentiation of Internet performance, simultaneously indicating new directions and areas for further research. First, in the case of the Internet, the core–periphery dimension is not universal and obvious, as regional systems are strongly marked. Second, perceiving the digital divide mainly through the prism of Internet access is an insufficient approach. At present, it can be treated as an unauthorised simplification. The importance of Internet performance has been additionally reinforced by the Covid-19 pandemic. The increase in the scope of Internet use has increased its dependence on good connection parameters. This clearly corresponds with the third-level digital divide. The benefits obtained from having a high-speed Internet – preferably symmetrical – are an important criterion for progressive, subsequent social stratification.

As Sanders and Scanlon (2021, p. 136) note, "With the advancement of technology comes the evolution of need". Hence, expectations of Internet performance are growing and will continue to do so as the range of services offered expands and their quality increases. In spatial research, we should look at the Internet from the perspective of its most important parameters, relations between them and particularly in terms of the symmetry of Internet speeds.

The results of this study are of vital importance for policy recommendations. In the case of Poland, we should note that regional and local Internet providers have turned out to be the most effective at providing a fast Internet connection. As such, they should be supported, especially in areas where investment is unprofitable from an economic point of view. This study also emphasises the important role of programs supporting high-quality Internet access, and their impact on the digitisation of the country, broadly conceived. This study has also enabled us to positively verify the usefulness for spatial analyses of data drawn from crowdsourced speed tests. The ability to use data that provide information about important aspects of Internet performance (for example, its symmetry) on a local scale is an invaluable resource in understanding the relationship between the individual categories of areas (for example, the core-peripheries, areas of growth-areas of stagnation, city-rural areas) and correlations between them.

We should also note the necessity of undertaking further research into the issues described (which can be performed in other countries as well, thanks to the comparability of data). It would seem particularly important that data regarding Internet performance be juxtaposed with data on social group characteristics and on levels of income and education. Doing so will enable us to grasp the invisible divide – that is, situations in which social and economic issues make it so that people cannot permit themselves access to high-speed Internet. Identifying such issues will enable better us to better understand how aspects of the digital divide relate to Internet performance. Of similar interest is research that accounts for the infrastructural dimension of space (e.g. highways). In both cases, however, there is a dilemma regarding the appropriate selection of units of analysis and research areas. We should also emphasise that, as regards the differences that emerge between various tests, it would be ideal to base research on data from multiple speed-test providers, averaging them out to get the best estimate of local speeds. A key challenge, however, is data coverage – whereas Ookla provides data for the entire world, many other databases are limited, for example, to the national scale.

Acknowledgement

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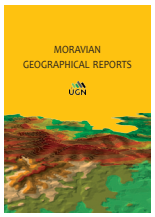

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The influence of administrative status on the trajectory of socio-economic changes: A case study of Polish cities

Katarzyna PRZYBYŁA [a *], Marian KACHNIARZ [a], Maria HEŁDAK [a], David RAMSEY [b], Bogdan PRZYBYŁA [c]

Abstract

Most of the academic literature indicates that high administrative status positively influences the development of a city, while the loss of such status leads to marginalisation. Most of these studies, however, investigated national capitals, and relatively little research has analysed the effect of a change in status at lower levels of government. Poland is an obvious subject for such research, due to the recent extensive reforms of its system of territorial government. This article presents the recent dynamics of socio-economic development in Polish cities and their relation to whether a city maintained or lost its status as a regional capital. These results enable us to identify correlations between the dynamics of socio-economic development and the status of a city. The nature of these correlations is more ambiguous than the results presented in previous studies. The findings of this study give new insight into the effect of changes in a city's administrative status.

Key words: *administrative status, level of socio-economic development of cities, territorial reform, Poland*

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1. Introduction

The effects of the administrative status of a city on its economic development are considered in this report. The authors address the questions of whether possessing the role of a regional capital has a significant effect on the development processes in a city and whether losing such status leads to marginalisation.

Based on classical theoretical models, it is generally thought that administrative functions play a significant role in the evolution of a city by determining its position in the hierarchy of a network of human settlements and having a positive influence on its socio-economic development. The existence of administrative functions in a city can lead to multiplier effects that influence other elements of the urban economy and lead to the further development of that city (Krugman, 1996; Markusen, 1996; Dascher, 2000; Heider et al., 2018). This view is shared by a large proportion of researchers and often treated as being intuitively obvious. Very little research has pointed out the negative effects of being a capital. The increasing frequency of public functions in the employment structure can weaken the dynamics of the development of a city by monopolising real estate and talented employees (de Vries and Sobis, 2018; Wendt, 2007; Heider et al., 2018). The bureaucratic culture of administration and management can have a negative impact on the local climate of innovation and enterprise (Polčse, 2015).

The trajectories of the development of cities have been used to investigate the phenomena described above. Analysis of the available literature, however, led the authors to three conclusions. Firstly, investigation of the role of administrative status on the development of cities has mainly been restricted to the consideration of national capitals and rarely to lower levels of the administrative structure. Secondly, these studies have often considered multiple factors, which has not enabled researchers to gain a clear view of the role of administrative status on the development processes of cities. Thirdly, in relation to the importance of administrative structure in forming public policies, very little research has been carried out at the level of regional government. As both Campbell (2000) and Gordon (2006) note, the enthusiasm of researchers for cosmopolitan megacities has come at the expense of investigating provincial capitals.

[a] Institute of Spatial Management, Wroclaw University of Environmental and Life Sciences, Wrocław, Poland (*corresponding author: K. Przybyła, e-mail: *katarzyna.przybyla@upwr.edu.pl*)

[b] Department of Computer Science and Systems Engineering, Wroclaw University of Science and Technology, Wrocław, Poland)

[c] Department of Mechanics of Structures and Urban Engineering, Wroclaw University of Science and Technology, Wrocław, Poland

The main goal of this article is to assess the level and dynamics of socio-economic development in Polish cities that are presently or were, prior to the administrative reforms, regional capitals. The authors also address the questions of whether a change in the administrative status of a city has had a significant effect on its development processes and whether losing the status of being a regional capital has led to marginalisation.

2. Theoretical background

The results of previous research generally confirm the significant effect of administrative status, including the loss of the status of being a capital, on the development trajectory of a city (Potts, 1985; Guerin-Pace, 1995; Gordon, 2002; Corey, 2004; Schatz, 2004; Bennett, 2010; Rossman, 2017). Except for the final study cited, these studies were individual case studies, based on simple non-parametric methods. Somewhat more advanced methodologies, based on the pattern of public sector investments, were used in the studies of Randall (1990), Lars-Hendrik and Waverman (2001), Swianiewicz and Łukomska (2004), Yigitcanlar et al. (2008); Polčse and Denis-Jacob (2010), Leigh and Blakely (2012), and Snieska and Zykiene (2015). Cities compete for these limited investment funds. Hence, in accordance with Christaller's Central Place model, capitals have a privileged position in accessing investment funds (Dascher, 2000). Thus, political, and administrative capitals have a specific advantage over cities that do not play such a role. Carroll and Meyer (1982) found that state spending in the USA was relatively higher in the state capitals than in other cities. Ma (2005) made similar conclusions regarding public spending in China. Moreover, Mayer et al. (2017) noted that, apart from having an advantage in accessing public funds, the administrative role of capitals leads to the creation of a specific institutional environment, which also favours the concentration of administrative functions in the private sector. Paddison (1983), Lea (2005) and Lessmann (2012) note that this effect depends on the level of decentralisation in a country and the role of the private sector in a country's economy. Research indicates that the higher the level of decentralisation in a country, the lower the regional disproportions in government spending.

Fundamental reforms of territorial administration are an ideal source for such studies. In countries with a stable political system, however, they are carried out very rarely. European studies have in recent times concentrated on two countries, Poland and Germany. Studies of the German system have covered both the transfer of the role of national capital from Bonn to Berlin and the effect of regional reforms at lower levels. Becker et al. (2018) present one of the most interesting studies in this field by comparing Bonn to 40 similar cities using the Difference-in-Differences and Synthetic Control methods. They found that Bonn underwent significant socio-economic growth after becoming the national capital. There was however no counteracting fall after its loss of this status. Several publications have been published on the effect of these reforms at regional and local level (Krippner, 1993; Dascher, 2000; Kauffmann, 2009; Holtmann et al., 1998; Heider et al., 2018). In general, the results of these studies confirm that the loss of political status leads to a tendency for socio-economic development to slow down slightly. This correlation is most marked when studies are based on the subjective opinions of representatives of local society. Quantitative studies, based on numerous socio-economic measures, give more ambiguous results.

Recent research on Polish cities leads to similar conclusions. Due to its fundamental reforms of territorial administration, Poland appears to be the best European subject for research in this field. Most of these studies, however, have only been published in Polish by national journals. Most of these studies find that cities which have lost the status of regional capital then develop at a slower rate, which indicates that administrative status is commonly a highly significant determinant of development (Dziemianowicz, 2000; Krysiński, 2013; Komorowski, 2012). In this context, concentrating public administration and, as a result, administrative functions, in the largest urban centres will only accelerate and deepen the socio-economic divide at regional and sub-regional levels (Heffner, 2011). The research of Łukomska (2011), however, observes a rather heterogeneous pattern of urban development processes. Kurniewicz and Swianiewicz (2016) present the most wide-ranging study in this field using the methods of Difference-in-Differences and Synthetic Control. In their opinion, the attribution of negative phenomena as resulting from a city's loss of status is subjective and is not confirmed by socio-economic measures of development. The real causes of the economic problems of some cities lie elsewhere (Łukomska and Swianiewicz, 2019). Similar conclusions were made by Przybyła (2022), who analysed, among other things, changes in the following: structure of the labour market; quality of life; and the level of investment by local governments, according to whether a city had retained or lost the role of regional capital. An interesting example of work by Polish authors on the consequences of administrative reform is Gendźwiłł, Kurniewicz and Swianiewicz (2021), which contains a systematic overview of 31 studies carried out in 14 countries. Their work analysed the association between changes in jurisdiction size and economic outcomes. They find that there are economies of scale regarding administrative spending, but not in other areas.

As argued above, although there is wide debate about these phenomena, the number of studies on this subject that use objective measures is surprisingly small. As Mayer (2017) observes, this does not hold only for Poland, but there is a lack of interdisciplinary studies (both theoretical and empirical) on the development of provincial cities. One of the goals of the authors is to, at least partially, address this gap.

Two hypotheses, based on the reviewed literature, are tested. The first hypothesis states that the level and rate of socio-economic development is associated with the status of a city. The second hypothesis states that there is an association between changes in population size and the level of socio-economic development.

3. Data and methods

Poland joined the EU on May 1st, 2004. Since the practical effects of the administrative reform became much more visible after accession and data collection was made more uniform at this time, this study covers the period 2004–2018. The 69 cities studied are split into three groups: current regional capitals (18), former regional capitals (31), other cities (20). The geographical location of these cities is presented in Figure 2. In preparation for Poland's accession to the European Union, major administrative reforms were implemented in 1999. These reforms reduced the number of administrative regions (województwa) from 49 to 16. Since the role of regional capital was shared in two of the newly formed regions (by Toruń and Bydgoszcz in Kuyavia-Pomerania and by Zielona Góra and Gorzów

Wielkopolski in Lubusz), this meant that 31 cities lost the status of regional capital, becoming the seats of counties. In addition, 20 other Polish cities have the administrative status of being a county (powiat).

3.1 Constructing a measure of a city's socio-economic development

To assess the economic performance of cities, most often researchers choose a set of variables and measures that reflect, directly or indirectly, the state and dynamics of a city's economy. Various studies on and measures of different aspects of development can be found in the literature (e.g. Przybyła et al., 2014; Przybyła et al., 2019; Kurtyka-Marcak, 2019; Hełdak et al., 2021; Moskowitz, 2021). Since the forms of data available are limited, particularly at the level of cities, the choice of measures is, by necessity, a compromise between the accessibility of the required data and their efficacy in assessing the aspects of economic development studied. On the other hand, the research goals determine which aspects of economic growth are considered.

No.	Aspect	Variable (X_j)
1	Housing stock	Mean housing space (m^2 per inhabitant)
2	Housing stock	Number of registered dwelling places per 100 married couples
3	Housing stock	Frequency of rent debt in local government housing (number of households in debt per 1,000 inhabitants)
4	Municipal infrastructure	Percentage of households connected to the water supply network
5	Municipal infrastructure	Percentage of households connected to the sewage network
6	Municipal infrastructure	Percentage of households connected to the gas network
7	Furnishing of houses	Percentage of households with a bathroom
8	Furnishing of houses	Percentage of households with central heating
9	Environmental protection	Percentage of population serviced by sewage works
10	Environmental protection	Percentage of particulate pollution emitted by heavy industry that is prevented by pollution reducing devices
11	Environmental protection	Investment in fixed capital aimed at environmental protection per inhabitant (NUTS 3) (PLN)
12	Environmental protection	Annual refuse per inhabitant, excluding segregated waste (kg)
13	Employment market	Mean monthly gross earnings relative to prices in 2004
14	Employment market	Percentage of working aged inhabitants registered as unemployed
15	Culture	Number of books in public libraries per 1,000 inhabitants
16	Culture	Number of Internet-connected computers accessible to the public in libraries, per 1,000 inhabitants (2008)
17	Culture	Number of museum visits per 10,000 inhabitants
18	Culture	Number of participants in events organised by cultural and social centres per 1000 inhabitants
19	Healthcare	Number of ambulances per 10 thousand inhabitants
20	Healthcare	Number of inhabitants per bed in a general hospital (NUTS 3)
21	Healthcare	Number of doctors and dentists per thousand inhabitants
22	Healthcare	Number of nurses and midwives per 10 thousand inhabitants
23	Healthcare	Number of inhabitants per general pharmacy
24	Nurseries	Number of nursery places per 100 children of age 0–3
25	Social care	Number of places in social care centres per thousand inhabitants
26	Nursery schools	Number of children in nursery schools per thousand children of age 3–5
27	Schools	Gross percentage of pupils in primary schools
28	Schools	Gross percentage of pupils in middle schools
29	Schools	Pass rate for the school leaving certificate (NUTS 3)
30	Demographics	Number of divorces per 1,000 inhabitants
31	Demographics	Population growth rate per 1,000 inhabitants
32	Demographics	Number of retired inhabitants per 100 inhabitants of working age
33	Demographics	Net migration per 1,000 inhabitants
34	Demographics	Infant mortality per 1,000 live births
35	Socio-economic activeness	Number of registered foundations, societies, and social organisations per 1,000 inhabitants
36	Socio-economic activeness	Budget income of the city (in PLN) per inhabitant relative to prices in 2004
37	Socio-economic activeness	Number of firms on the REGON register per 10,000 inhabitants
38	Socio-economic activeness	Number of self-employed individuals per 100 thousand inhabitants of working age
39	Socio-economic activeness	Investment by firms per inhabitant relative to prices in 2004
40	Socio-economic activeness	Gross value of fixed stock in firms per inhabitant relative to prices in 2004

Tab. 1: Diagnostic traits used. Source: authors' research

To characterise the socio-economic development of cities, this study uses a taxonomic method based on comparisons with an "ideal". This method enables the construction of a synthetic measure that considers several variables associated with development. Such measures give a multi-dimensional appraisal of various aspects of development and enable an overall description of the socio-economic changes occurring in the objects of study. In addition, such measures can be used to create rankings of these objects (Pomianek, 2010; Kachniarz et al., 2019; Świąder et al., 2016). They can also be applied in decision making systems, enabling the integration of various aspects of development policy by taking a wide spectrum of factors into account when making decisions (Kazak et al., 2017).

The chosen method allows us to rank a set of objects (here, cities) that are characterised by a set of diagnostic variables that by nature are positive or negative indicators of development (stimulators or de-stimulators). The values of the observations of the measure of socio-economic development are scaled in the interval [0,1], such that larger values indicate a higher level of development.

Based on an initial analysis of the nature of socio-economic development, several diagnostic traits were selected and statistical data describing these traits were gathered from the Polish Central Statistical Office (Główny Urząd Statystyczny – GUS). Table 1 presents these traits, the variables used to measure them, and the aspects of development assessed: e.g. housing stock, environmental protection, and socio-economic activity. Although these are not all the traits that can be considered by such research, they give a reasonable overview of various aspects of socio-economic development.

Due to the low value of the coefficient of variation (< 0.06 in both years considered), the following quasi-constant traits were eliminated from further consideration: Traits 4, 5, 7, 27 and 29. The correlation matrix for the remaining 35 variables was constructed using Pearson's correlation coefficient. Due to the extremely large correlation of variables 32 and 38 with other variables, it was decided to omit these variables from further analysis. The variables omitted from the analysis are highlighted in grey in Table 1. As a result, we obtained a set of 33 traits to be analysed in the study (see Appendix 1 – Statistical Data). Since increases in the values of variables 3, 12, 14, 20, 23, 30, 34 correspond to lower levels of socio-economic development, these variables were defined to be de-stimulators. Next, de-stimulators were converted into stimulators using Equation (1). This ensures that large values of each of the variables used correspond to desirable traits.

$$X_j = -X_i \tag{1}$$

where X_i = the value of a de-stimulator and X_j = the corresponding value after transforming X_i into a stimulator.

Subsequently, the values of the features adopted for the analysis were standardised according to the following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j} \tag{2}$$

where z_{ij} = standardised value of the j-th feature for the i-th subject; x_{ij} = value of the j-th feature for the i-th subject; $\bar{x}_j$ = mean value of the j-th feature; and S_{ij} = standard deviation of the j-th feature.

After standardisation, the variance of each diagnostic variable is equal to 1, whereas the mean of each is equal to 0. Hence, the effect of each variable on the indicator of socio-economic development is independent of the scale it is measured in (Pluta, 1986).

At this stage, each of the variables has been transformed to a unit-free indicator. These indicators have comparable ranges. In each case, large (positive) indicators correspond to more desirable values of the underlying variable and thus to high levels of socio-economic development. Analogously, negative indicators correspond to less desirable values of the underlying variable and thus to low levels of socio-economic development. The ideal value of such an indicator is defined to be the maximum value observed for that indicator. The ideal pattern of development is then defined as the one in which each indicator takes the maximum value observed, i.e.:

$$z_0 = [z_{01}, z_{02}, \dots z_{0j}, \dots, z_{0m}] \tag{3}$$

where $z_{0j} = max_i \{z_{ij}\}$.

Similarly, the anti-ideal pattern z_{-0}, is defined as the one in which each indicator takes the minimum value observed i.e.:

$$z_{-0} = [z_{-01}, z_{-02}, \dots z_{-0j}, \dots, z_{-0m}] \tag{4}$$

where $z_{-0j} = min_i \{z_{ij}\}$.

Next, the Euclidean distance between subject i and the ideal pattern of development, d_{i0}, is calculated using Equation (5):

$$d_{i0} = \sqrt{\sum_{j=1}^{m} \left(z_{ij} - z_{0j}\right)^2} \tag{5}$$

The Euclidean distance between the ideal pattern of development and the anti-ideal, d_0, is calculated using Equation (6)

$$d_0 = \sqrt{\sum_{j=1}^{m} \left(z_{0j} - z_{-0j}\right)^2} \tag{6}$$

Finally, the measure of development for subject i, m_i, is calculated using Equation (7).

$$m_i = 1 - \frac{d_{i0}}{d_0} \tag{7}$$

for i = 1,…, n.

According to Equation (7), the more similar the indicators corresponding to subject i are to the ideal values (i.e. the smaller the distance d_{i0}), the greater the value of the measure of socio-economic development, m_i.

The subjects are classified according to the measure of the level of socio-economic development, m_i, into four classes based on the measure's arithmetic mean, $\overline{m}$, and standard deviation, s_m:

Class A (the highest level of development)

$$m_i > \overline{m} + s_m$$

Class B (medium-high level of development)

$$\overline{m} + s_m \geq m_i \geq \overline{m}$$

Class C (medium-low level of development)

$$\overline{m} > m_i \geq \overline{m} - s_m$$

Class D (lower level of development)

$$m_i < \overline{m} - s_m$$

where m_i is the value of the synthetic measure for subject i.

3.2 Statistical analysis

A significance level of 5% is used in all testing procedures. To analyse the relations between the status of cities and both the mean level of development and changes in the level of development, we used ANOVA (Analysis of Variance) and the Kruskal-Wallis test (non-parametric, used due to the relatively small sample sizes – approximately twenty cities in each of the three groups). It is also unclear whether the measure of the level of development comes from a normal distribution. To ensure a conservative testing procedure, the largest p-value from these tests is reported. Hence, to infer that the level of development varies according to the status of a city, both test results must be significant. To compare the level of development in two groups of cities, the student t-test was used in conjunction with the Bonferroni-Hochberg correction for multiple testing.

To analyse the relation between the population of cities and both the level of development and changes in the level of development, Spearman's correlation coefficient was applied. This was done since the distribution of the population of cities clearly does not follow a normal distribution.

4. Results

Based on the research procedure, we obtained measures of socio-economic development for each of the studied cities in 2004 and 2018. These measures of development differ significantly according to both time and location. The level of socio-economic development of each city was clearly higher in 2018 than in 2004 (see Fig. 1). In 2004, Cracow (Kraków) had the highest measure of socio-economic development, 0.411, while Bytom had the lowest, 0.222. In 2018, the highest ranked was Warsaw (Warszawa, measure 0.601), while the lowest ranked was Świętochłowice (0.291).

4.1 Classification of cities according to socio-economic development

The socio-economic development of the cities studied were classified based on the mean and standard deviation of the measures of socio-economic development. Cities in Class A (the highest ranked) were associated with measures of socio-economic development greater than the mean plus the standard deviation. Those in Class D (the lowest ranked) were associated with measures of socio-economic development lower than the mean minus the standard deviation.

Based on the measures of socio-economic development in 2004, thirteen cities are placed in Class A (the most highly developed): Cracow, Warsaw, Zielona Góra, Katowice, Olsztyn, Opole, Krosno, Rzeszów, Poznań, Bielsko-Biała, Lublin, Nowy Sącz and Zamość (the mean of the measures for this group is 0.37 with coefficient of variation 4.3%). Four

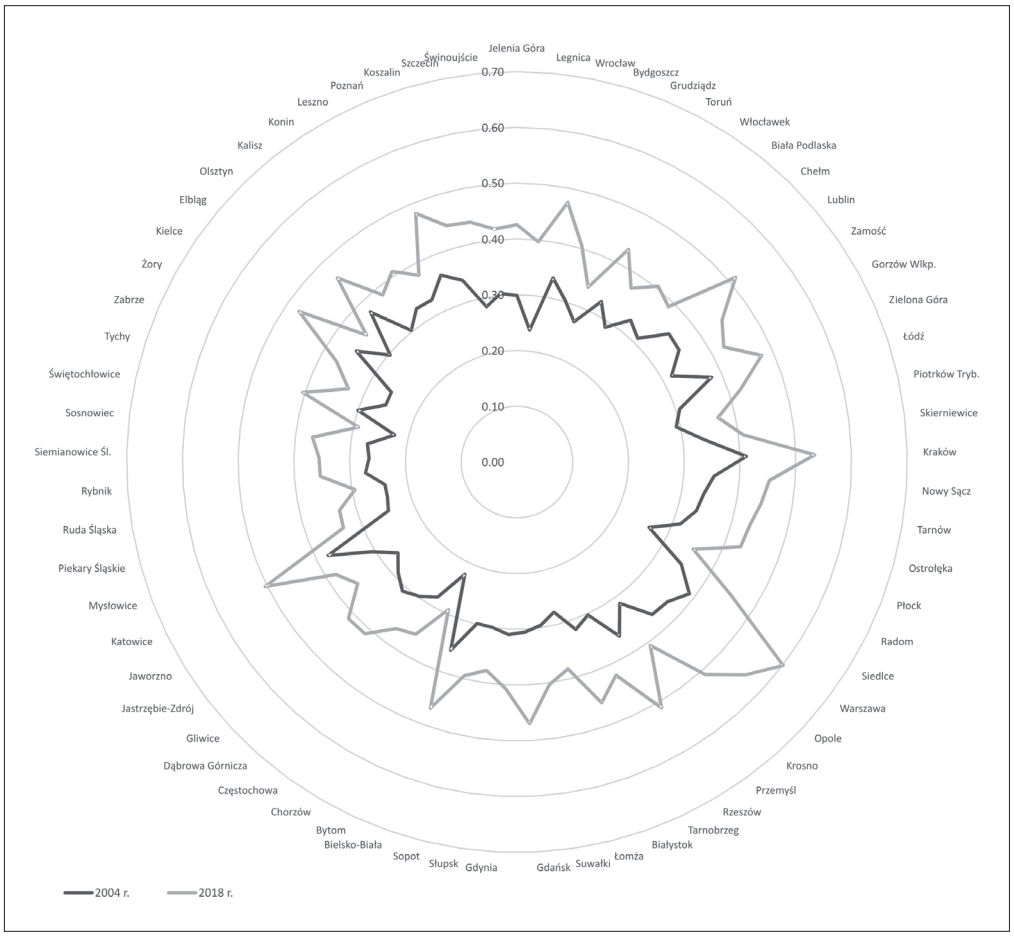

Fig. 1: Level of socio-economic development of cities based on similarity to an ideal
Source: authors' elaboration

of these cities, Krosno, Bielsko-Biała Nowy Sącz and Zamość, are former regional capitals, whereas the remaining cities continue to play the role of regional capital.

Based on the results from 2018, the following cities are categorised as Class A: Warsaw, Opole, Cracow, Lublin, Rzeszów, Krosno, Katowice, Poznań and Zielona Góra (the mean of the measures for this group is 0.521 with coefficient of variation 7%). It should be noted that, apart from Krosno, all these cities hold the status of regional capital.

Based on the results from 2004, fifteen cities are classified as Class B (above average). The mean of the measures of socio-economic development in this group is 0.33 with coefficient of variation 3.4%. It should be noted that all the cities in this class held the status of regional capital before the administrative reforms (five of these cities have retained this status). Based on the results from 2018, twenty cities are classified as Class B. The mean of the measures of socio-economic development in this group is 0.44 with coefficient of variation 4.1%. It should be noted that only one city that did not previously have the role of regional capital, Świnoujście, was classified in this group and as the lowest ranked.

Based on the measures of socio-economic development in 2004, the number of cities placed in Class C (below average) is 27, the largest class. The mean of the measures of socio-economic development in this group is 0.29 with a coefficient of variation 4.3%. Moreover, 29 cities are categorised as Class C based on the results from 2018. The mean of the measures of socio-economic development in this group is 0.38 with a coefficient of variation 5.3%. A mixture of all three types of city (present regional capital, former regional capital and other cities) are found in this category.

In 2004, the small group of class D cities (lowest developed) included ten cities. The mean of the measures of socio-economic development in this group is 0.25 with a coefficient of variation 6%. Two of these cities are former regional capitals, while the remaining eight are from the group of other cities. In 2018, only seven cities belonged to this class. None of these cities had previously been a regional capital. The mean of the measures of socio-economic development in this group is 0.32 with a coefficient of variation 6.4%.

It should be noted that, except for the city of Grudziądz located in the central-northern province of Kujavia-Pomorania, all the cities categorised as Class D in 2018 belong

Class A	m_i	Class B	m_i	Class C	m_i	Class D	m_i
Kraków	0.411	Kielce	0.350	Chełm	0.310	Siemianowice Śląskie	0.265
Warszawa	0.389	Siedlce	0.347	Gdynia	0.310	Radom	0.264
Zielona Góra	0.381	Koszalin	0.340	Dąbrowa Górnicza	0.309	Żory	0.258
Katowice	0.378	Tarnów	0.340	Łódź	0.307	Zabrze	0.257
Olsztyn	0.376	Skierniewice	0.337	Gdańsk	0.305	Mysłowice	0.247
Opole	0.368	Wrocław	0.336	Jaworzno	0.305	Piekary Śląskie	0.241
Krosno	0.365	Ostrołęka	0.333	Świnoujście	0.304	Ruda Śląska	0.240
Rzeszów	0.362	Konin	0.329	Kalisz	0.303	Legnica	0.238
Poznań	0.362	Leszno	0.328	Bydgoszcz	0.302	Świętochłowice	0.224
Bielsko-Biała	0.358	Biała Podlaska	0.326	Tarnobrzeg	0.302	Bytom	0.222
Lublin	0.357	Toruń	0.325	Tychy	0.300		
Nowy Sącz	0.354	Białystok	0.318	Słupsk	0.300		
Zamość	0.353	Gorzów Wlkp.	0.317	Jelenia Góra	0.299		
		Przemyśl	0.313	Sopot	0.298		
		Płock	0.313	Częstochowa	0.298		
				Elbląg	0.297		
				Suwałki	0.296		
				Piotrków Tryb.	0.292		
				Gliwice	0.291		
				Włocławek	0.289		
				Szczecin	0.284		
				Chorzów	0.281		
				Łomża	0.277		
				Rybnik	0.272		
				Grudziądz	0.272		
				Sosnowiec	0.270		
				Jastrzębie-Zdrój	0.269		

Tab. 2: Measures of the socio-economic development of Polish cities in 2004, together with their classification
Legend: light grey – regional capitals (group I), dark grey – former regional capitals (group II), white – other cities with the administrative status of "county" (powiat; group III).
Source: authors' calculations

Class A	m_i	Class B	m_i	Class C	m_i	Class D	m_i
Warszawa	0.601	Kielce	0.475	Gliwice	0.413	Grudziądz	0.338
Opole	0.560	Wrocław	0.474	Dąbrowa Górnicza	0.411	Mysłowice	0.333
Kraków	0.534	Gdańsk	0.470	Konin	0.409	Piekary Śląskie	0.330
Lublin	0.513	Bielsko-Biała	0.468	Skierniewice	0.408	Zabrze	0.329
Rzeszów	0.511	Olsztyn	0.461	Gdynia	0.408	Ruda Śląska	0.294
Krosno	0.509	Białystok	0.457	Przemyśl	0.407	Bytom	0.292
Katowice	0.504	Nowy Sącz	0.454	Bydgoszcz	0.406	Świętochłowice	0.291
Poznań	0.481	Siedlce	0.451	Biała Podlaska	0.405		
Zielona Góra	0.479	Zamość	0.447	Tychy	0.404		
		Tarnów	0.444	Suwałki	0.403		
		Koszalin	0.442	Legnica	0.397		
		Szczecin	0.438	Sopot	0.394		
		Ostrołęka	0.433	Chełm	0.389		
		Toruń	0.431	Kalisz	0.384		
		Płock	0.429	Łomża	0.382		
		Jelenia Góra	0.426	Jaworzno	0.382		
		Gorzów Wlkp.	0.424	Leszno	0.378		
		Łódź	0.422	Słupsk	0.378		
		Tarnobrzeg	0.421	Włocławek	0.373		
		Świnoujście	0.420	Żory	0.370		
				Piotrków Tryb.	0.369		
				Sosnowiec	0.369		
				Częstochowa	0.369		
				Jastrzębie-Zdrój	0.359		
				Chorzów	0.358		
				Siemianowice Śląskie	0.355		
				Rybnik	0.354		
				Elbląg	0.353		
				Radom	0.352		

Tab. 3: Measures of the socio-economic development of Polish cities in 2018, together with their classification
Legend: light grey – regional capitals (group I), dark grey – former regional capitals (group II), white – other cities with the administrative status of "county" (powiat; group III).
Source: authors' calculations

to the Upper Silesian conurbation. This region is undergoing a difficult period due the transformation away from a coal-based economy. Combined with the effect of globalisation and de-industrialisation, this has led to an increase in social inequality, as observed in other regions of a similar nature. (see: Filion et al., 2019; Bae, Joo, 2020).

It should be noted that each of the four classes exhibited a higher coefficient of variation in the measures of socio-economic development in 2018 than in 2004. This increase is also visible at the level of the whole set of cities (13.5% in 2004 and 15% in 2018). This indicates a general increase in inequality between levels of socio-economic development in Polish cities.

4.2 Analysis of the measure of socio-economic development in 2004

There is a highly significant association between the status of a city and the measure of socio-economic development (for both the Kruskal-Wallis test and analysis of variance, $p < 0.001$).

Status of a city	Mean	Standard deviation
Current capitals (group I)	0.3472	0.0354
Former capitals (group II)	0.3152	0.0306
Other (group III)	0.2715	0.0278

Tab. 4: Measure of socio-economic development in 2004 and the status of a city
Source: authors' calculations

Pair	p-value
Current capitals – Former capitals	0.0013
Current capitals – Other cities	< 0.001
Former capitals – Other	< 0.001

Tab. 5: Pairwise comparison of socio-economic development between groups
Source: authors' calculations

Fig. 2: Map of the regional administrative system and geographic location of Class D cities in 2018
Source: authors' research project

Comparing the three groups pairwise, it can be observed that the measure of development is significantly greater amongst the current capitals than amongst the former capitals, where it is in turn greater than amongst the other cities (based on the Student t-test applying the Bonferroni-Hochberg procedure for multiple testing).

The correlation between the size of a city and its level of socio-economic development is not significant (Spearman's test of correlation, $r = 0.2039$, $p = 0.1032$).

4.3 Analysis of the measure of socio-economic development in 2018

Again, there is a highly significant association between the status of a city and the measure of socio-economic development (for both the Kruskal-Wallis test and analysis of variance, $p < 0.001$).

Comparing the three groups pairwise, it can be observed that the measure of development is significantly greater amongst the current capitals than amongst the former capitals, where it is in turn greater than amongst the other cities (based on the student t-test applying the Bonferroni-Hochberg procedure for multiple testing).

There is a significant positive correlation between the population size of a city and its measure of socio-economic development in 2018 (Spearman's correlation coefficient, $r = 0.3511$, $p = 0.0041$).

Status of a city	Mean	Standard deviation
Current capitals (group I)	0.4794	0.0501
Former capitals (group II)	0.4100	0.0381
Other (group III)	0.3595	0.0411

Tab. 6: Measure of socio-economic development in 2018 and the status of a city. Source: authors' calculations

Pair	p-value
Current capitals – Former capitals	< 0.001
Current capitals – Other cities	< 0.001
Former capitals – Other	< 0.001

Tab. 7: Pairwise comparison of socio-economic development between groups of cities
Source: authors' calculations

The results of the study indicate a clear association between the status of a city and its level of socio-economic development, in both 2004 and 2018. Current regional capitals exhibit a higher level of development than former regional capitals, which in turn exhibit a higher level of development than cities that never possessed such a status. In additional, in 2018 larger cities exhibited a higher level of socio-economic development.

4.4 Analysis of the absolute change in the development measure in the period 2004–2018

Both the Kruskal-Wallis test and analysis of variance indicate that there exists a significant association between the absolute increase in the measure of development over the period 2004–2018 and the status of a city ($p < 0.001$ in both cases).

Comparing these types of city pairwise, the absolute increase in the development measure is significantly higher amongst current capitals than amongst the remaining two groups of city. There is no significant difference between the absolute increase in the development measure between former capitals and cities that never possessed the status of regional capital (student t-test using the Bonferroni-Hochberg procedure for multiple testing).

Spearman's test of correlation indicates that there is a positive correlation between the absolute increase in the development measure and the population of a city ($r = 0.3664$, $p = 0.0027$).

It follows from this analysis that current regional capitals are characterised by a greater increase in socio-economic development in the period 2004–2018 than the remaining cities. These cities were not only more highly developed at the beginning of the period, the absolute gap between the regional capitals and the remaining cities grew over the study period. It should be noted that the absolute increase in the level of development was similar amongst both former regional capitals and cities that never possessed the status of regional capital.

Status of a city	Mean increase	Standard deviation
Current capitals (group I)	0.1322	0.0334
Former capitals (group II)	0.0948	0.0252
Other (group III)	0.0880	0.0179

Tab. 8: Status of a city and the absolute change in the development measure in the period 2004–2018
Source: authors' calculations

Pair	p-value
Current capitals – Former capitals	< 0.001
Current capitals – Other cities	< 0.001
Former capitals – Other	0.3800

Tab. 9: Pairwise comparison of the absolute increase in the development measure between types of city
Source: authors' calculations

4.5 Analysis of the relative change in the development measure in the period 2004–2018

Both the Kruskal-Wallis test and analysis of variance indicate that the relative (percentage) increase in the development measure is associated with the status of a city ($p < 0.001$ in both cases).

The percentage increase in the development measure is greatest amongst the current capitals. Comparing these groups pairwise, the rate of growth in current capitals is significantly greater than amongst the former capitals and close to being significantly greater in comparison with cities that never possessed the status of regional capital. The rate of development in this third group of cities was slightly (but not significantly) greater than amongst the former regional capitals (student t-test using the Bonferroni-Hochberg procedure for multiple testing).

There is a positive, but non-significant, association between the population of a city and the relative increase in the measure of socio-economic development (Spearman's test of correlation, $r = 0.2404$, $p = 0.0537$).

Status of a city	Mean percentage increase	Standard deviation
Current capitals (group I)	38.43	10.04
Former capitals (group II)	30.50	9.852
Other (group III)	32.35	5.401

Tab. 10: Status of a city and relative change in the development measure in the period 2004–2018
Source: authors' calculations

Pair	p-value
Current capitals – Former capitals	0.013
Current capitals – Other cities	0.056
Former capitals – Other	0.478

Tab. 11: Pairwise comparison of the relative increase in the development measure between types of city
Source: authors' calculations

The analyses of the relative changes in the measure of socio-economic development largely confirm the conclusions made based on the absolute changes in this measure. Taken together, these analyses indicate that not only are the absolute differences in the level of socio-economic development between the current regional capitals and the remaining cities growing, but the relative differences are also increasing. The rate of development amongst former capitals and cities that were never regional capitals is comparable (it is marginally higher in the latter group).

4.6 Analysis of changes in population

In addition, the relative changes in the populations of cities (measured at the level of individual cities and not groups) and their association with the measure of socio-economic development were analysed.

4.6.1 Relative changes in population in the period 2004–2018

The Kruskal-Wallis test indicates that there is a significant association between the percentage change in the population of a city and the status of that city ($p = 0.0050$).

Comparing the types of city pairwise, the relative fall in the population of both former regional capitals and cities that never possessed this status is greater than in current

Status of a city	Mean percentage increase	Standard deviation
Current capitals (group I)	0.021	8.141
Former capitals (group II)	– 4.916	3.585
Other (group III)	– 6.412	3.802

Tab. 12: Percentage change in population size and the status of a city
Source: authors' calculations

regional capitals, in which there was no significant change of population size (student t-test using the Bonferroni-Hochberg procedure for multiple testing).

The regional capitals are characterised by larger populations than the remaining two types of city (both in 2004 and in 2018). The latter two types of city are characterised by populations of a similar size. The process of depopulation is observable in both of these types of city.

Pair	p-value
Current capitals – Former capitals	0.0048
Current capitals – Other cities	0.0012
Former capitals – Other	0.3416

Tab. 13: Pairwise comparison of the relative change in population between types of city
Source: authors' calculations

4.6.2 Association between the change in population and the development measure

Spearman's test of correlation indicates that there exists a significant positive correlation between the percentage change in population and

1. The measure of socio-economic development in 2004;
2. The measure of socio-economic development in 2018; and
3. The absolute change in the measure of socio-economic development in the period 2004–2018.

This indicates that the level of socio-economic development is a factor affecting people's decision to move to or remain in a city.

Pair	Spearman's r	p-value
% change in population – development measure in 2004	0.4699	< 0.001
% change in population – development measure in 2018	0.4874	< 0.001
% change in population – absolute change in development measure in the period 2004–2018	0.3304	0.0072

Tab. 14: Association between the change in population and the development measure
Source: authors' calculations

5. Discussion

The analysis has generally confirmed the hypotheses formulated in the introduction, namely that both the level and rate of change of socio-economic development are higher in the regional capitals than in the remaining cities. Not only was the level of socio-economic development greater in the regional capitals when Poland joined the EU, the absolute difference in the level of development has grown since then. It seems reasonable to assume that this process will continue. Hence, we conclude that administrative status is a significant factor in determining the level and speed of development, i.e. the first hypothesis formulated in the introduction has been confirmed.

Moreover, our results indicate that there is a significant positive correlation between the level of socio-economic development in a city and the percentage change in its population. It follows that the regional capitals, which are simultaneously generally the larger cities in Poland and form the core of the regions' development potential, exhibit more positive (or at least, less negative) patterns of demographic change than the remaining cities. The populations of the regional capitals have generally remained stable, while the remaining cities have generally undergone depopulation. This confirms the second hypothesis formulated in the introduction.

The group of cities exhibiting the highest level of development (Class A) are clearly dominated by current regional capitals. The one exception is Krosno, which lost its status as a regional capital in the 1999 reforms. As stated above, this might lead us to conclude that losing this status (as in the case of cities in group II) leads to a significant change in the trajectory of socio-economic development. Our study indicates that cities that lost their status as regional capitals have a lower level of socio-economic development than cities that continued to be regional capitals, and the absolute distance between these groups increased over the study period. It cannot be concluded from this, however, that this loss of status has limited their opportunities for development. In the authors' opinion, the administrative status of a city is of secondary meaning in determining its potential for development when it does not result from the position of the city in the hierarchy of the geographical pattern of settlements. Most cities in Class A play the role of metropolitan areas. According to the polarisation-diffusion model of growth, the hierarchy of cities results mainly from their population sizes. The cities grouping together the main functions for development become regional capitals. Cities whose importance lies at a more local level have lower potential for development, even if they retain the status of regional capital. This seems to be confirmed by the fact that even at the beginning of the study period (2004), the cities that lost their status as regional capitals exhibited a lower level of socio-economic development than cities that retained their status. These were cities that even before the administrative reforms had higher positions in the hierarchy. Cities that lost their status as regional capitals continued to develop at a similar rate to those that never played the role of regional capital. This indicates that the status of regional capital is of secondary importance.

Hence, it seems that the results obtained in this study cannot be explained by one simple theory. In general, the trajectory of socio-economic development results from various social, economic, and technical factors. Instead of looking for a universal set of factors and conditions for socio-economic development, one should use a more hybrid approach. According to Drobniak (2018, p. 24), some cities rapidly adapt to novel situations, while others retain their old structure. One may talk about multiple transformation dynamics resulting from the interaction between institutional, social, economic, and geographic factors. This seems to be confirmed by the set of cities in Class B, in which a mixture of current and former regional capitals can be found. The only current regional capital in Class C is Bydgoszcz (which shares this status with Toruń and is thus lowly ranked in the hierarchy of regional capitals). The members of this class are generally former regional capitals that have a peripheral location with respect to the main centres of development. The lowest ranked cities (Class D) in 2018 are cities that have never played the role of regional capital. With one exception, these cities are part of the Upper Silesian conurbation, which is undergoing a difficult transformation from a coal-based economy. One may argue that this factor is the main determinant of these cities' low position in the ranking.

In summary, the results of this study indicate that at present the largest cities in Poland, which simultaneously play the role of regional capitals, have the best conditions for socio-economic development. For the main part, the effects of the political status of a city result from its naturally high position in the network of socio-economic interactions. This fact should be stressed, particularly when we consider the nature of the decision processes leading to the precise form of the new administrative map of Poland. This was influenced by objective factors, such as the size of a city or its distance from other urban centres. It was also influenced, however, by, for example, prominent politicians, local communities and disagreements between various experts (Kowalczyk, 2000; Miszczuk, 2003; Habuda and Habuda, 2014). On the other hand, the results regarding the effects of a loss of status of being a regional capital are somewhat ambiguous. Hence, our conclusions are more like those made by Łukomska (2011), as well as by Kurniewicz and Swianiewicz (2016), than to Dziemianowicz (2000) and Krysiński (2013), who concluded that former regional capitals then developed at a slower rate due to this loss in status. In the light of our study, the observation that the development of a city has been constrained due to such a loss of status is a subjective feeling, which is not necessarily confirmed by objective socio-economic indicators. Moreover, negative changes in these indicators may result from factors such as geographical location, the size of a city and its economic structure, and not from the results of administrative reform itself. These results are in line with other studies on chosen aspects of urban development (Przybyła and Kachniarz, 2017; Przybyła et al., 2018; Przybyła et al., 2020). For example, studies on the investment activities of cities that retained or lost the status of regional capital (Przybyła et al., 2020; Przybyła, 2022) indicate, for example, that several less developed former regional capitals currently exhibit an above average level of investment activity. This indicates that, apart from the availability of external funds, a well-developed strategy and high-quality administration are also instrumental in promoting development. Making use of the funds and opportunities that are available can lead to the initiation and/or acceleration of development processes, as well as counteracting the effects of previous marginalisation.

6. Conclusions

This study has been based on a model for ranking the socio-economic development of Polish cities based on a set of diagnostic traits using data from 2004 (when Poland joined the EU) and 2018. The measure used is based on a wide range of clearly defined indicators associated with various spheres of socio-economic development, such as the availability of housing, environmental protection, and socio-economic activity. For this reason, it may be argued that this measure is relatively objective.

The results of the study indicate that the level of socio-economic development of Polish cities in 2018 was significantly higher than in 2004. The greatest level of change was observed in cities that retained the status of regional capital, particularly when compared with cities that had lost this status. In 2004, however, the cities that retained the status of regional capital already had a higher level of socio-economic development than those cities that lost this status, which in turn had a higher level of development than other cities (administrative centres at a lower level, poviat). Those cities that retained the status of regional capital continued to develop at a faster rate than other cities. On the other hand, the cities that lost the status of regional capital developed at a comparable rate to the cities that were never regional capitals. Hence, one should not state that the loss of administrative status was the main factor in these changes. The dynamics of change are subject to a range of factors. On the other hand, one may state that the influence of administrative reforms on development processes is visible, but not determinative.

Further investigation indicated a significant positive correlation between the population of a city and the measure of socio-economic development. It follows naturally from this that there exists a positive association between possessing the status of regional capital and socio-economic development. Considering the larger populations of regional capitals, together with the flows of migrants to these cities, it may be concluded that the distance between the regional capitals and other cities will continue to grow.

Socio-economic stagnation does not always automatically follow the loss of status as a regional capital. It is observed more frequently in such cities, however. This conclusion is simultaneously a call to widen and deepen research on the factors affecting the trajectory of socio-economic development in urban centres.

In the light of the heterogeneous pattern of changes observed, further research on the level and dynamics of socio-economic development in Polish cities should not only consider their administrative status, but also consider, for example, the geographical location of cities. A spatial analysis of these changes might be particularly useful in explaining some of the variation seen in our analysis. In conclusion, the authors plan to carry out a cluster analysis, to classify Polish cities according to the variation in underlying factors.

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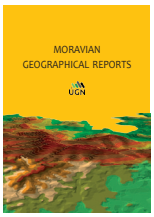

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Local centres in post-socialist suburbs: Redefined concept and retrofitting perspectives

Dorota MANTEY [a] *

Abstract:

Chaotically developed post-socialist suburbs need retrofitting by providing residents with a local central space. This research aims at developing a typology of suburban local centres, describing the most common central spaces according to adopted criteria, as well as identifying which type of local centre has the most potential to be perceived as such by suburbanites and how suburban municipalities plan central spaces. The research was conducted in six institutional Warsaw suburbs representing the most common types of local centres of a neighbourhood catchment area. The research has shown that spatial criteria differentiate local centres more than social criteria. Concentric layouts attract different non-residential functions more effectively than linear ones. When recognising some spaces as central, the legibility of the broader spatial arrangement and the presence of key objects with centre-forming functions seems to be important. Factors that distort such recognition include the excessive dispersion of buildings, shops, and service points; peripheral or random location of the main activity node; poorly designed and equipped central spaces; and the proximity to large-scale shopping centres and recreational areas/objects. When looking for a model of retrofitting post-socialist suburbs through strengthening neighbourhood centres, it is worth recalling the concept of the so-called "third places".

Keywords: *local centre, neighbourhood, suburbs, retrofitting. Warsaw, Poland*

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1. Introduction

After the rapid suburbanisation in post-socialist Europe in the 1990s, which was well recognised and described in the literature (Tsenkova and Nedović-Budić, 2006; Sýkora and Ouředníček, 2007; Pichler-Milanović et. al., 2007; Tammaru et al., 2009; Hirt, 2012; Stanilov and Sýkora, 2014; Dinić and Mitković, 2016; Taubenböck et al., 2019), a new need has emerged, namely retrofitting chaotically developed suburbs. It is a response to negative connotations of urban sprawl, such as irrational spatial structures, dispersion, cultivating auto-dependence, disproportionately depleting energy, land, and water resources, social isolation, mono-functionality, a considerable proportion of gated communities, and the lack of planned public spaces (Zuziak, 2005; Chmielewski, 2005; Zimnicka and Czernik, 2007; Mantey, 2011; Springer, 2013; Solarek, 2013; Kępkowicz and Mantey, 2016).

The only feasible way to make post-socialist suburbs more sustainable is treating them as defective neighbourhood units that need to be reinforced by improving their compactness (Mantey and Pokojski, 2020) and overcoming mono-functionality. In contemporary planning theory, a polycentric spatial structure or deconcentration of non-residential functions in the whole city region are promoted. As a consequence, there are many different types of suburban central spaces increasingly finding new locations on the outskirts of big cities, including exhibition, logistic, office, industrial, and technological centres. Apart from supralocal concentrations of functions, there are also activity nodes of a neighbourhood catchment area. This type of central space fulfils the everyday needs and organises the local life of the community.

In this context, two terms seem to be of special importance: neighbourhood and local central space. When reviewing different definitions of a neighbourhood, Park and Rogers (2015) synthesise them into a statement that a neighbourhood is a collection of people who share services and some level of cohesion in a geographically bounded place. Thus, there are three keywords defining neighbourhoods, namely people, place, and cohesion. Local centre (LC), in turn, can be defined broadly as a multifunctional public space providing access to basic (everyday) services, but also favouring social integration and building the territorial

[a] Faculty of Geography and Regional Studies, University of Warsaw, Warsaw, Poland (*corresponding author: D. Mantey, e-mail: *d.mantey@uw.edu.pl*)

identity of the residents (Damurski et al., 2018), or shortly, as a hub of activity (Dinić and Mitković, 2016). A properly developed community centre is one of the most powerful urban design elements to achieve social sustainability at the neighbourhood scale, because of its importance to, influence on, and positive social externalities towards the local community (Medved, 2017). Because the terms "neighbourhood" and "community" are sometimes interchangeable concepts, the "neighbourhood centre" often becomes synonymous with the term "community centre" (*ibidem*).

The need for more local life in the neighbourhood is in line with the climate change context of sustainability and the need for radical solutions when tackling this problem. Besides, the idea of decentralised, compact, mixed use neighbourhoods have become more apparent due to the Covid-19 pandemic (O'Sullivan, 2021). As more people work remotely and want to live further away from the city centre, certain planning concepts have re-emerged.

Taking these changes into account, the aim of the article is threefold:

1. To develop a typology of LCs based on the criteria that refer to the concept of a neighbourhood unit;
2. To identify whether LCs determined in accordance with the typology are perceived as such by the residents (the research is based on selected Polish suburbs – see Fig. 1);
3. To recognise the approach of suburban municipalities towards planning LCs.

As a result, this paper should contribute to the development of the model of retrofitting Polish suburbs through reinforcing neighbourhood local centres. This reinforcement will draw from the critique of the neighbourhood unit concept and the basic principles of designing the central space. The typology based on universal criteria as well as the general recommendations of how to retrofit Polish suburbs, can be used in other post-socialist countries as well, since the origins of different types of suburbs in this part of Europe are to some extent similar, although the pace of suburban transformations varies (Ouředníček, 2007; Zębik, 2011; Dinić and Mitković, 2016; Mantey and Sudra, 2019; Zévl and Ouředníček, 2021).

2. Theoretical background: central space in the context of suburban neighbourhoods

In the context of chaotically developed post-socialist suburbs and the need to retrofit them, the concept of suburbs as imperfect neighbourhoods is worth implementing. Taking into account different spatial scales in which neighbourhoods can be considered (Park and Rogers, 2014) and the conditions for creating suburban central space, which is a key element in the retrofitting process, the 'institutional neighbourhood' seems to be the most suitable spatial scale for further considerations. The American Planning Association (2006) emphasises that an institutional neighbourhood is bounded by some degree of official limits of institutions. It needs to be big enough to provide multiple services such as schools, health centres, recreational and social facilities, and shopping centres (Park and Rogers, 2015). The spatial scale of institutional neighbourhoods is appropriate for the public sector to be involved in land use planning, transportation, economic development, open space and social services provision, commercial revitalisation, meeting residential needs or environmental issues. It also enables conducting statistical analysis since administratively distinct settlement units are often the lowest level of data collection (Airgood-Obrycki, 2019).

In the process of retrofitting suburbs, finding appropriate and feasible ways to increase density without negative effects is relevant for current planning discussions (Talen, 2009). From the viable neighbourhood and social sustainability perspective, the location of basic public facilities, such as schools or shops, is of particular importance. When achieving social goals at the neighbourhood scale, properly developed neighbourhood central spaces that enhance walking and strengthen local ties is one of the most powerful urban

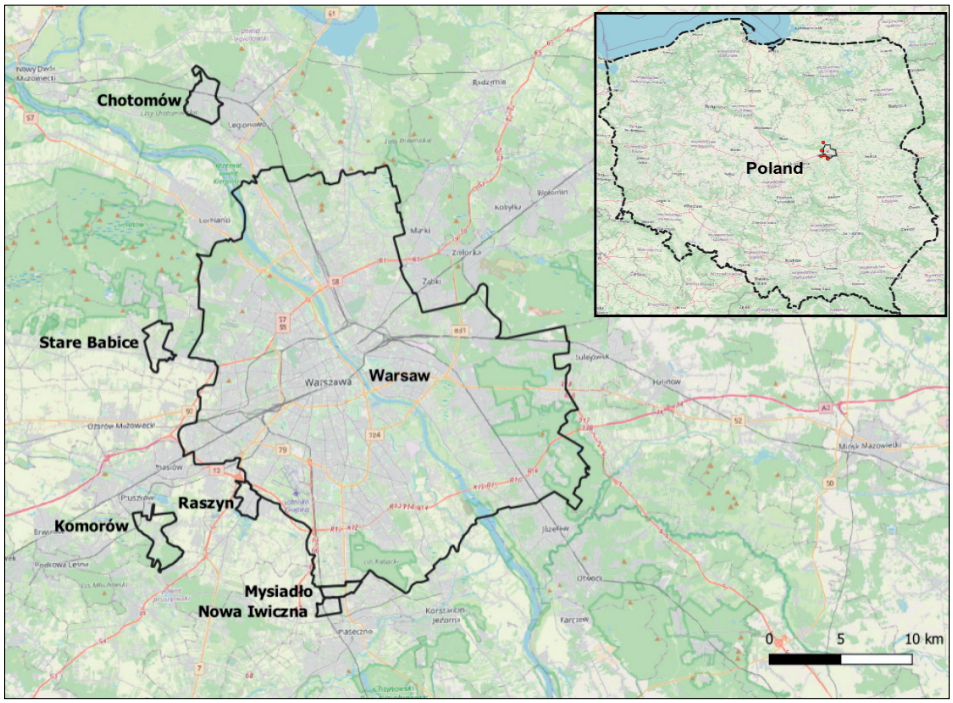


Fig. 1: Suburbs selected for the study
Source: Wojciech Pokojski; used with permission

design elements. The concept of a "centre" is considered in two dimensions: functional and spatial. In the functional dimension, the centre is identified with a small area where various functions and activities are concentrated, while the spatial dimension denotes a specific position of a given area in the structure of the settlement unit as a whole (Hillier, 1999) – the centre structures the urbanised area and gives it meaning (Jałowiecki and Szczepański, 2006). Taking into account the spatial dimension, the suburban centre can be related to the concept of nodes of K. Lynch (1960). Nodes are represented by road intersections, public transport stops or concentrations of retail and service points. A legible, specific layout of the node is not necessary for its recognition, although a well-developed node that stands out from the surroundings is more easily perceived by the residents as a central space.

If we consider the leading function, two types of central space can be distinguished: (1) commercial centre and (2) community centre. The second type is closely related to C. Perry's (1929) concept of the neighbourhood unit that organises the space around a community centric lifestyle and pushes away heavy traffic as well as local shopping areas to the edges of the socio-spatial entity. Its critique, however, raises the issue of separation of the neighbourhood unit that leads to segregation by function, and provides very poor access to essential services and destinations, although it protects residential neighbourhoods from disruptive traffic (Mehaffy et al., 2015). The modified concept of central space based on transit through the neighbourhood unit could be a response to this criticism. Community services and shops reinforce each other most effectively when they are spatially associated with the main street – "movement economy" (Porta et al., 2012), while in Perry's concept, community services are located in the very centre of the unit and shops on its edges. Moreover, by not centring neighbourhoods on arterials or main crossroads, they cannot be serviced cost-effectively by public transit (Poticha, 2008, after: Mehaffy et al., 2015).

In terms of spatial scale and location, there are two main categories of suburban centres. The first one is represented by the concentration of large-scale objects gathering all the functions of the high street under one roof (Hardwick, 2004) and targetted at the residents of both the city and the suburban areas: big box stores, multiplex cinemas, and large supermarkets. These objects are located on the edges of settlement structures or at some distance from them, alongside the main transportation routes and nodes, at visually exposed sites, as an adaptation of land uses to expanding catchment areas of such suburban centres. There is usually no public space that would bind together land parcels on which particular objects are situated, so they do not promise developing any proper links or relations with their surroundings in the future (Bajwoluk, 2015). This spatial form is characteristic of the North American suburbs. Many such big-box complexes, however, have undergone intensive modernisation processes in recent years (Dunham-Jones and Willianson, 2009; Tachieva, 2010; Marique, and Reiter, 2014; Talen, 2015). Car-oriented shopping malls, as described above, have been turned into multi-functional walking- and public transit-conducive centres.

The second main category of suburban centres represents a neighbourhood catchment area and take the form of a cluster of a few non-residential functions at a distance of no more than 100 m from each other (parameters according to Mantey and Pokojski, 2020). The set of units of non-residential function includes schools, places of religious worship, small scale service and retail premises, local administration offices and cultural objects. Such a centre is typical of old suburbs with the preserved compact development structure, which do not easily yield to transformations or accommodate new spatial solutions. When reviewing the literature on suburban local centres, the research on utility programs of suburban high streets are noteworthy (Gryffiths et al., 2008). Interestingly, the viability of suburban centres located along high streets is not determined solely by trade. It tuns out that most people visiting suburban centres choose them for reasons other than shopping, and the vitality of such places depends, on the one hand, on the degree of diversification of activities that can be undertaken there, and on the other hand, on the location of the centre in the system of residents' routes and in the system of transport connections (Hillier, 1999; Vaughan and Gryffiths, 2013). There is also research on pedestrian traffic and its importance in the context of the vitality of suburban central spaces (Boarnet et al., 2011; Vaughan and Geddes, 2014).

In the process of densification of suburban settlements, infill and redevelopment strategies of reinforcing local centres can be used. Infill strategy aims at implementing new non-residential functions to vacant sites. Although the strategy seems to be simple in its assumptions, its implementation may encounter many barriers, like the cost of land acquisition, regulatory restrictions, and neighbourhood groups opposing the introduction of non-residential functions (Farris, 2001). Redevelopment strategy, in turn, suggests a comprehensive improvement of existing urban structures with the involvement of developers' capital (Talen, 2011, 2012). The United States is a good example of a country where this strategy is being implemented successfully, although redevelopment is difficult to accomplish in fully-developed suburbs (Scheer, 2001). Due to zoning regulations (Hirt, 2013) and the reluctance of American suburbanites to locate anything other than housing in their neighbourhood, many retrofitting projects based on multi-functional centres cannot be implemented in the existing suburbs. American urbanists, however, were the first to suggest re-developing, re-inhabiting, or re-greening "dead" shopping malls or commercial corridors based on New Urbanism principles (Dunham-Jones and Wlliamson, 2009; Tachieva, 2010; Talen, 2015). These principles are also visible in mixed-use settlement units with local centres, which take the form of new towns (e.g. Serenbe) or rebuilt and extended old ones along the railway lines (e.g. Duluth, Suwanee, and Norcoss, near Atlanta). Despite quite different contexts of suburbanisation (large-scale developers' greenfield projects and high intensity of deconcentration processes), American retrofitting projects may provide some inspiration in the search for better solutions to be adapted in post-socialist transformations, namely: spatial scale, location, social-mix, the range of functions, quality of urban and architectural projects, and the engagement of developers' capital.

3. Data and methods

The search for opportunities to make Polish suburbs more sustainable has been preceded by the development of a typology of suburban local centres (LC) with commercial and social functions. The criteria of a new typology are based on the literature review. They refer to the criticism of C. Perry's (1929) concept of a neighbourhood unit, and reflect to some extent new issues under debate: social and economic diversity, maintenance of viable pedestrian and public transit

modes, viability of internalised community service hubs, and efficient use of energy and natural resources (Mehaffy et al., 2015).

Urban layout, form and location of a local centre seems to be conditional for its economic vitality, while civic and commercial uses concentrated on a relatively small area enhance walking and stimulates local life. These assumptions make the foundations for the typology which is based on four categories of criteria: (1) catchment area, (2) spatial form, (3) functions, and (4) location (Bajwoluk, 2015). They correspond with the two dominant models of suburban development in post-socialist Europe:

1. New development in the form of scattered mono-functional settlements on former agricultural land, adjacent to the existing urban fabric or completely independent of it (Tammaru et al., 2009, after: Dinić and Mitković, 2016);
2. Infills and small spatial extensions of existing settlements (Zévl and Ouředníček, 2021).

These two models of suburban development create different conditions for the retrofitting post-socialist suburbs. The typology presented in this article is intended to facilitate the description of local centres and draw attention to their retrofitting potential, hence the focus was rather on justifying the typological criteria than providing examples of all possible types of LCs, especially as we do not know if all the types exist (this may be the subject of further research).

3.1 Catchment area

Catchment area is of primary importance. It determines the remaining criteria of the typology. Multifunctional walking- and public transit-conducive centres can be developed at three scales: (1) the neighbourhood, (2) the municipality, or (3) a quadrant of the metropolitan region (Filion et al., 2016). In opposition to the process of retrofitting North American suburbs that usually focuses on large multifunctional suburban centres (Dunham-Jones and Williamson, 2009), this article suggests the neighbourhood scale of transformation as the most conducive to local community building. Therefore, the typology is dedicated exclusively to the neighbourhood catchment area. The other two scales have been omitted.

3.2 Spatial form

The criterion described as spatial layout in which the LC is embedded reflects the basic street framework that determines the concentration of services. Spatial arrangement can be easily identified by visual inspection of satellite images provided by the Google Maps or Google Earth applications. The typology distinguishes three main spatial layouts:

1. Concentric layout – services concentrated around a common space or a point, where the main roads converge;
2. Linear layout – services located along main road or its section;
3. Scattered layout – a single multifunctional object or a few objects of non-residential functions located within a quarter of streets that do not form a centripetal system.

In all these layouts, commercial and public objects are located at no more than 100–130 m from each other (Mantey and Pokojski, 2020). Bajwoluk (2015) adds one more type of the LC, namely a large-area centre. This category, however, is dominated by supermarkets and big-box service facilities with external parking lots. Due to the neighbourhood scale of local centres under study, this type was not included in the typology.

The location of a LC within the spatial arrangement of the suburb and the network of streets determines walkability and the ease of access for the majority of residents, and thereby translates into the economic vitality of the central space. Identified spatial layouts of LCs enable a description of various types of post-socialist suburbs and suburban housing: new residential developments, core-village suburbs, old suburbs modelled on garden cities, and transformed recreational summer cottages (Ouředníček, 2007, Hirt and Stanilov, 2007). The concentric layout (Fig. 2) is more common in planned garden-cities and core-village suburbs. The linear layout (Fig. 3) is typical for the suburbs that spread along the main road, which during the transformation period has become a natural space for locating non-residential functions. Scattered layout (Fig. 4) often accompanies new suburbs characterised by developers' housing estates and a network of parallel roads linked by perpendicular connectors (in Poland, this layout refers to the unfavourable spatial structure of previous rural land), or represents older settlement units (often former rural village) with a grid street scheme.

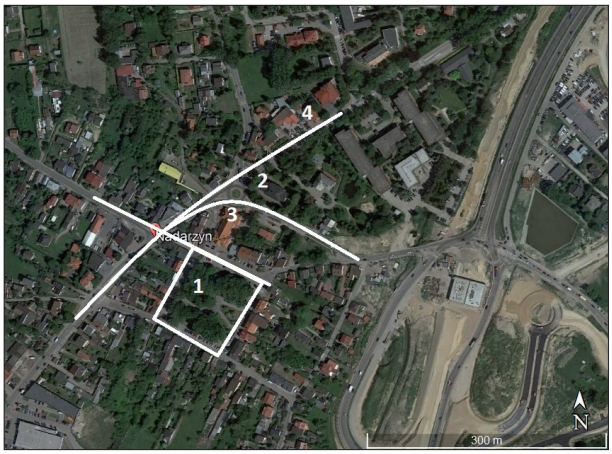


Fig. 2: Example of concentric layout of LC in Nadarzyn, Poland (main objects: 1 – green square, 2 – church, 3 – library and community house, 4 – police station)
Source: Google Earth Pro, 22 June 2022

Fig. 3: Example of linear layout of LC in Jesenice, Czech Republic (main objects: 1 – square, 2 – municipal office, 3 – supermarket, 4 – police station)
Source: Google Earth Pro, 22 June 2022

The second criterion reflecting spatial form of the LC is the type of nucleus/core around which the central space was developed. Based on the seven forms of the LC's core identified as part of a project aimed at creating a network of local centres in Warsaw (Happach and Sadowy, 2015), the typology presented in this paper takes into account only five of them – those that are widespread in the suburbs, namely: (1) a paved square, (2) a green square, (3) a commercial street/ road, (4) a commercial and service building, (5) a polycentre, which includes a few scattered equally important centre-forming objects (synergy effect turns the entire area into a local centre), and adds two more forms, which are predestined to originate an activity node: (6) a train station, and (7) a main crossroad. The type of a LC's core reflects the history of the suburb, but also affects the attractiveness of the central space, safety for its users, and conditions for the location of specific functions. Some cores (e.g. historical market square) may be symbolic for the whole suburb.

3.3 Location

The location of a suburban local centre remains in a cause-and-effect relationship with the advantages of accessibility and frequency of use of the various functions. The location is usually considered in relation to (1) the boundaries of the neighbourhood (central, peripheral, and outside the neighbourhood), and (2) the main roads and communication nodes, walking routes, bike paths, and public transport stops, analysed together with the frequency of public transport services[1].

Fig. 4: Example of scattered layout of LC in Ivanka, Slovakia (main objects: 1 – recreational area, 2 – school) Source: Google Earth Pro, 22 June 2022

Fig. 5: Community centre at the edge of Żółwin, Poland Source: Google Earth Pro, 22 June 2022

In the Perry's neighbourhood unit model, a centrally located community centre (social, cultural, and recreational amenities) is segregated from commercial uses at the edges, since retail and services tightly connected with fast vehicle arterials are expected to protect the interior of the neighbourhood from traffic and noise. Following the criticism of this concept, it is better when mixed-use central space as a driving force for the social and economic vitality of the whole neighbourhood, is centred and well connected by a street network. The main activity node of the organically growing suburbs is more often located centrally, especially in the case of fully-planned or core-village suburbs, while in new suburban settlement units arising spontaneously, without a predetermined road system, LC develops much later than residential functions, hence it is located peripherally, sometimes even at some distance from residential buildings, which intensifies spatial and functional chaos (Fig. 5).

When it comes to the proximity to the public transport infrastructure, the typology focuses solely on the major transportation nodes and public transport stops (the frequency of public transport services has been omitted). In many cases, suburban LCs are located at some distance from train stations or main bus stops (many bus stops are located alongside supralocal arterials that are peripheral to or outside the neighbourhood). This is in line with Perry's concept, although it has been shown that the integration of public transportation and land use through transit-oriented development (TOD) programs yields important sustainable benefits (National Academies…, 2004; Curtis et al., 2009). For the densification of the suburbs, public transport connecting spaces of everyday life is more important than public transport on mega-infrastructures that are not integrated into the neighbourhood (Young and Keil, 2010). The preferred location of a local centre is in walking distance to most houses, at the convergence of pedestrian, cycle, and bus/train routes, at the point of maximum connectedness (Vall-Casas et al., 2011). This implies centring neighbourhoods on arterials or main roads in order to make transit service more cost-effective and more viable (Poticha, 2008, after: Mehaffy et al., 2015). Moreover, a modified model of the neighbourhood unit should contribute to reducing carbon emissions and its ecological footprint by better access to public transport.

3.4 Functions

Assuming that a centre is constituted not only by the space, but also by the functions, it is worth emphasising that a LC should be a single destination for civic, institutional, and commercial functions (Medwed, 2017). Functional integration allows institutionally different types of activities and different categories of people to coexist side by side. LCs as the basic public spaces should enable residents to undertake necessary activities (those that we are obliged to do, such as going to work, school, shopping, etc.), optional activities (those that we want or feel like doing), and social activities (assuming voluntary human interaction) (Gehl, 1987). In addition to the types of activity, the very position of each service in the hierarchy is also important for the social and economic vitality of space. Services can be assigned to three levels of service nodes (Damurski et al., 2015):

[1] It is suggested to aim for at least six buses/ trains per hour (Rice, 2010)

1. The level of basic services (BS): the presence of small convenience stores, car-service points, small playing fields, public transport stops;
2. The level of basic centre-forming services (BC-FS): the presence of public services of an everyday nature (education, health, administration, sport and recreation, culture), medium-sized commercial facilities, eateries, and crafts;
3. The level of centre-forming services (C-FS): the presence of large-area and specialised trade, as well as public and commercial services of a higher ranking (upper secondary schools, hospitals, stadiums, museums, tourism, entertainment, etc.).

Since the subject of the analysis are local centres of the neighbourhood catchment area, the typology takes into account mainly the first two levels.

In addition to focusing on meeting basic needs, an important feature of LC is enabling residents to lead their own lifestyle. Suburbanites often demand attractive and well-equipped recreational areas. In post-socialist Europe, many such spaces have been created in recent years and financed from European Union funds. If such an area is located in the immediate vicinity of the LC, then the central space is enriched with an additional element strengthening its social function and attractiveness. The combination of retail, service, and recreational functions makes suburban public space more vital (Mantey, 2019), therefore outdoor recreational space should play an important role in the process of retrofitting suburbs.

As a final effect, the new typology of suburban LC of a neighbourhood catchment area is built on six criteria and a set of the most frequent situations within each of them (Tab. 1).

After developing the typology, six institutional Warsaw suburbs[2] have been selected for further research, namely: Nowa Iwiczna (municipality of Lesznowola), Mysiadło (municipality of Lesznowola), Chotomów (municipality of Jabłonna), Komorów (municipality of Michałowice), Stare Babice (municipality of, Stare Babice), and Raszyn (municipality of. Raszyn). Although the Warsaw Metropolitan Area differs from other city regions in Poland (it is the largest and the fastest-growing urban region in Poland, with the highest share of the affluent metropolitan class), it has the most diversified suburbs in terms of their origin, spatial layout, and location in relation to transportation routes and public transport. Finally, local centres of the six selected suburban settlements have been characterised according to the criteria of the typology. They represent various but common forms of concentration of non-residential functions in suburban neighbourhoods on the outskirts of Warsaw. Additionally, residents of the suburbs under study were asked to indicate which space they perceived as local centre. This information was obtained in the survey conducted in June 2021 via Facebook. Basic information about the respondents is presented in Table 2. The sample is not representative for the study area, since the survey was rather aimed at initial insight into residents' perception than inference about the population from a sample. The respondents were also asked to list preferred objects and functions for the LC in their neighbourhood.

In the last stage of the research, central spaces designated according to adopted criteria and spaces indicated by residents as local centres have been confronted with spatial policies[3] of suburban municipalities. For this purpose, directions of spatial development have been analysed.

4. Results

In search of the most effective solutions for the retrofitting Polish suburbs, the criteria of the new typology have been divided into two groups describing (1) spatial and (2) social potential of the central space (Tab. 3). The basis for distinguishing individual types of LC is their spatial potential resulting from the urban layout and form, while the social potential expressed in the hierarchy of service nodes and the presence of recreational areas additionally differentiate each type. Table 4 presents examples of the types of local centres that are characteristic of Warsaw suburbs. They have been designated and then described according to the adopted framework presented in Table 3. It has been

Category of criterion	Criterion	Possible situations
Spatial form	(1) Spatial layout in which the LC is embedded	1. concentric; 2. linear; 3. scattered (not embedded in a legible spatial arrangement)
	(2) Spatial form of the LC's core	1. market square; 2. green square; 3. main crossroads; 4. sector of a local or supralocal commercial street/ road; 5. commercial, service, or public utility building; 6. outdoor green/ recreational area; 7. a few scattered equally important centre-forming objects
Location	(3) Location of the LC within the neighbourhood	1. central; 2. peripheral
	(4) Location of the main public transport stop/station	1. within LC; 2. outside LC
Functions	(5) Hierarchy of services	1. basic services; 2. basic centre-forming services; 3. centre-forming services
	(6) The presence of an outdoor recreational area of at least 1,000 m^2	1. LC with an outdoor recreational area; 2. LC deprived of an outdoor recreational area

Tab. 1: Criteria of the typology of suburban LCs of a neighbourhood catchment area
Source: author's elaboration

[2] Institutional suburb is an administrative unit (usually a village). This scale of suburbs enables the municipality to shape the street layout and to equip the suburb with infrastructure, public facilities, and public objects.

[3] In Poland, each municipality is obliged to prepare its spatial policy, which is a document called the Study of the Conditions and Directions of the Spatial Development of a Municipality.

	Chotomów	Komorów	Stare Babice	Nowa Iwiczna	Raszyn	Mysiadło	Total
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
				sample			
Gender							
female	35 (39.8)	56 (69.1)	58 (63.7)	50 (78.1)	66 (75.9)	47 (73.4)	368 (67.5)
male	53 (60.2)	25 (30.9)	33 (36.3)	14 (21.9)	21 (24.1)	17 (26.6)	177 (32.5)
Age							
18–25	13 (14.8)	19 (23.5)	14 (15.1)	16 (25.0)	13 (15.1)	11 (17.2)	95 (17.4)
25–34	32 (36.4)	15 (18.5)	19 (20.4)	6 (9.4)	24 (27.9)	18 (28.1)	126 (23.0)
35–44	24 (27.3)	20 (24.7)	31 (33.3)	25 (39.1)	30 (34.9)	17 (26.6)	162 (29.6)
45–59	11 (12.5)	20 (24.7)	22 (23.7)	15 (23.4)	15 (17.4)	15 (23.4)	120 (21.9)
above 59	8 (9.1)	7 (8.6)	7 (7.5)	2 (3.1)	4 (4.7)	3 (4.7)	44 (8.0)
population (year)*	5,810 (2019)	4,584 (2018)	2,202 (2015)	4,073 (2019)	7,244 (2014)	3,684 (2019)	

Tab. 2: Characteristics of the respondents. Source: author's elaboration
*Note: * The Central Statistical Office in Poland does not publish demographic data at the village level, hence population data comes from different websites, including official websites of the municipalities, but this is not always the most recent data.*

assumed that a suburban LC of a neighbourhood catchment area should include at least three neighbourhood-scale units of non-residential functions, at a distance of not more than 100–130 m from each other (Mantey and Pokojski, 2020). Each LC categorised according to the new typology has been juxtaposed with a map derived from the spatial policy of the municipality under study and spaces that are perceived as local centres by the residents.

4.1 LCs designated according to adopted criteria

The research on institutional suburbs has showed that spatial criteria differentiate local centres more than social criteria. Considering spatial potential, several characteristic structures in which local centres are embedded can be identified, while in the case of social criteria, the vast majority of the LCs are similar and offer not only basic, but also public services, and many of them are equipped with recreational space as well (Tab. 5). Most suburban LCs do not constitute a compact, well-planned entity. Moreover, the study of local centres of a neighbourhood catchment area has revealed that suburban structure features a very local form of activity, limited to small-scale service units mixed with private houses.

The type of suburban LC is strongly related to the origin of a given suburb. The best-formed LCs are common among the pre-World War II suburbs (the so-called old suburbs). Some of them follow the garden city concept with a centrally located railway station (Komorów), others are former rural villages developed around the market square with a church as the landmark (Stare Babice, Fig. 6). Pre-war suburbs have a legible concentric layout. Small shops and service points are concentrated around the core, while schools, larger stores, and other public services are in the 'second line' or slightly further. Old suburbs are also represented by urban villages well connected with the nearby city (Zimnicka and Czernik, 2007). Most of the urban villages are not comprehensively planned. They have rather enlarged systematically in a chaotic manner as a result of infills and small spatial extensions of existing settlements. The core of such suburbs is usually a school or other important public building. After the mass suburbanisation period, some suburbs of this type have initiated the retrofitting process based on a newly built market square (Raszyn, Fig. 7). It happens, however, that instead of being conducive to social integration, the new core space serves a merely decorative function or expresses the desire to create a new identity of the suburb.

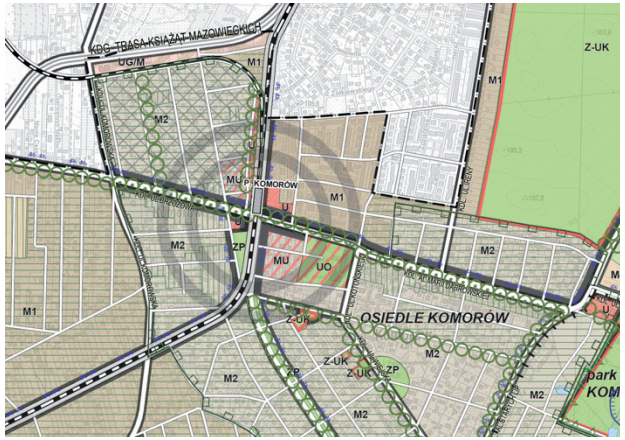
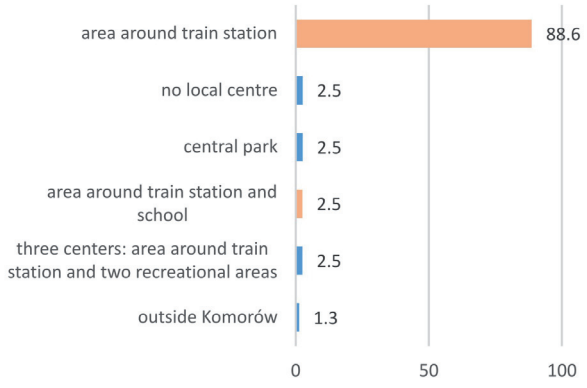
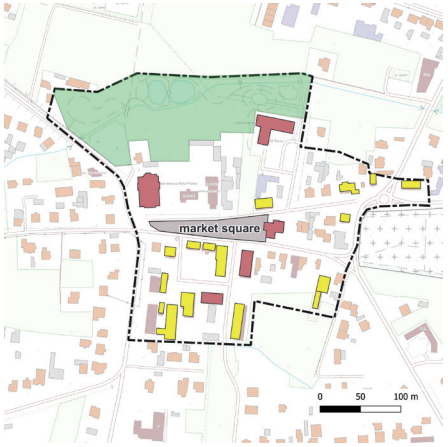
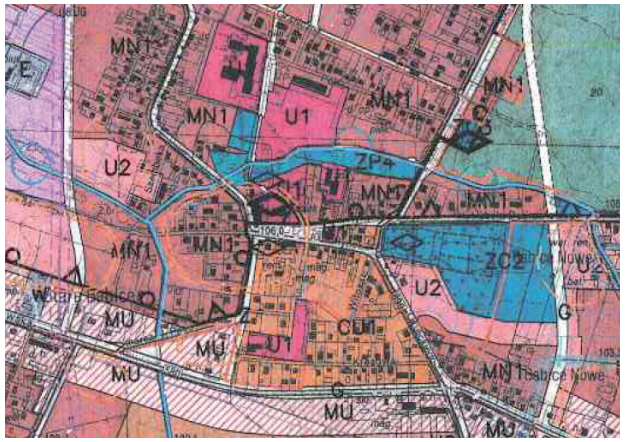
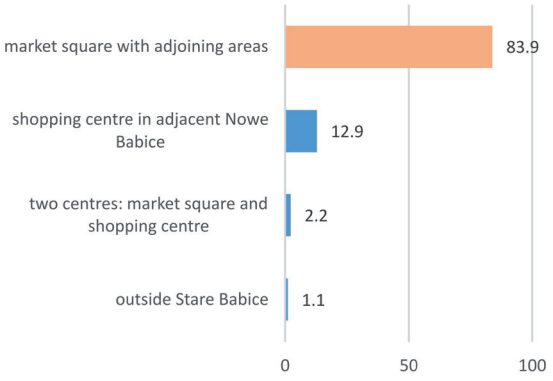
In Poland, new suburbs often have no central point that organises the spatial structure of the entire suburb. In the case of suburban settlements that spontaneously developed from linear rural villages, the role of LC is often played by a section of the main road. The rural origin of such suburbs is clearly outlined in pre-existing development alongside the road, where small shops and services are mixed with houses of old residents (Chotomów). It may happen that the central space of this type is located peripherally, thus exacerbating the effect of spatial disintegration of a given suburb (Mysiadło). When spontaneously developed, linear LCs are generally unattractive. They do not encourage people to stay there longer than necessary, although they have the potential to become a significant space. This can be done by transforming them into a promenade, providing meaningful images, giving the suburbs their own identity (old buildings and historical objects alongside the main road).

In new suburbs, LCs can also take the form of a block of streets around a school or other public building, thus providing greater spatial compactness of central space and sometimes higher social value compared to linear centres. This category of central space is represented by the polycentric type of LC (Nowa Iwiczna). The impetus for the development of this type of centre is the location of a public building within the existing urban fabric. This building attracts other equally important facilities that are clustered in a random block of streets, previously not planned for such functions. A polycentric LC with underdeveloped commercial functions is typical of chaotically developed new suburbs with an illegible spatial arrangement.

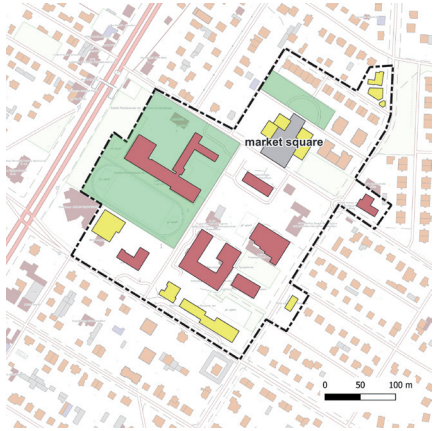
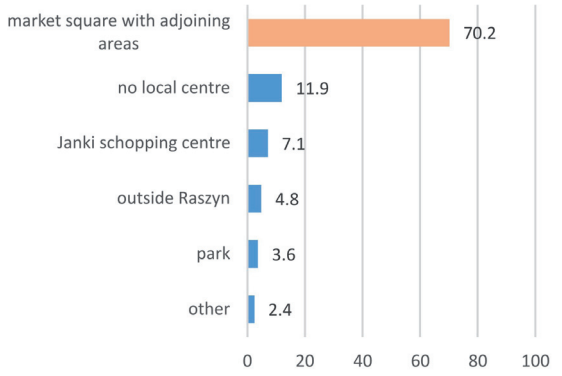
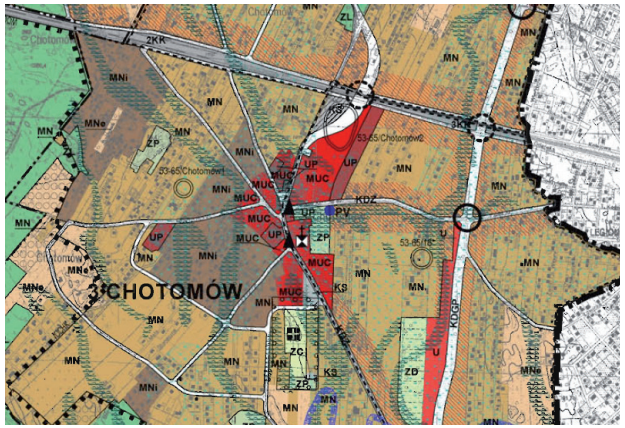
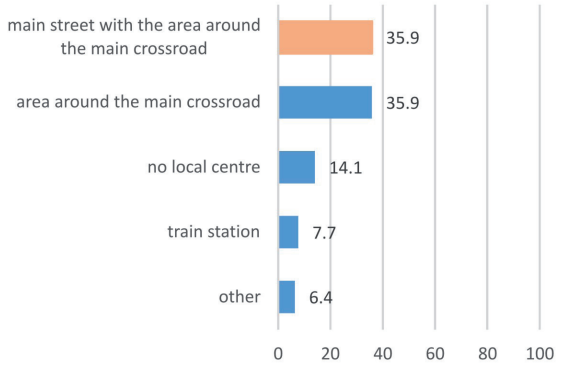
In the case of new suburbs, important transport nodes are often located peripheral to LCs. No vacant land and the predominance of private ownership make it difficult for the local authorities to implement public functions around such

SPATIAL POTENTIAL				SOCIAL POTENTIAL	
(1) Spatial layout of LC	(2) Spatial form of the LC's core	(3) Location of LC within the neighbourhood	(4) Location of the main public transport stop/station	(5) Hierarchy of services	(6) The presence of an outdoor recreational area of at least 1,000 m^2
1. concentric	1. market square 2. green square 3. main crossroads	1. central	1. within LC	1. basic services 2. both basic and basic centre-forming services 3. both centre-forming services and other services	1. LC with an outdoor recreational area 2. LC deprived of an outdoor recreational area
2. linear	4. sector of a local commercial street	1. central 2. peripheral	1. within LC 2. outside LC		
	5. sector of a supralocal commercial road	2. peripheral	1. within LC	4. centre-forming services 3. both centre-forming services and other services	
3. scattered (not embedded in a legible spatial arrangement)	6. commercial, service, or public utility building	1. central 2. peripheral	1. within LC 2. outside LC	1. basic services 2. both basic and basic centre-forming services 4. basic centre-forming services 5. centre-forming services	not applicable
	7. outdoor green/recreational area			1. basic services 4. basic centre-forming services	1. LC with an outdoor recreational area
	8. a few scattered equally important centre-forming objects		1. within LC 2. outside LC	6. two or more equally important basic centre-forming services, few or no basic services 7. two or more equally important centre-forming services, few or no basic services	1. LC with an outdoor recreational area 2. LC deprived of an outdoor recreational area

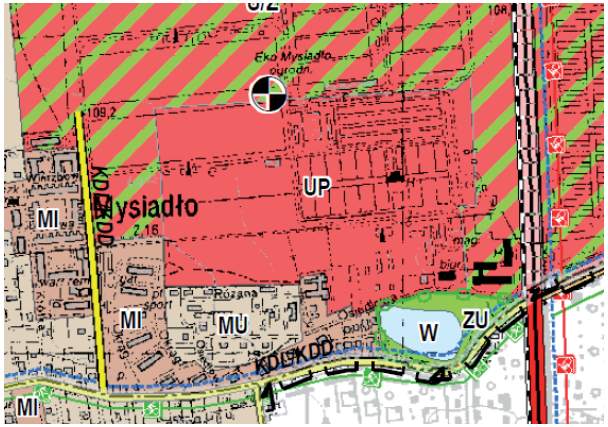
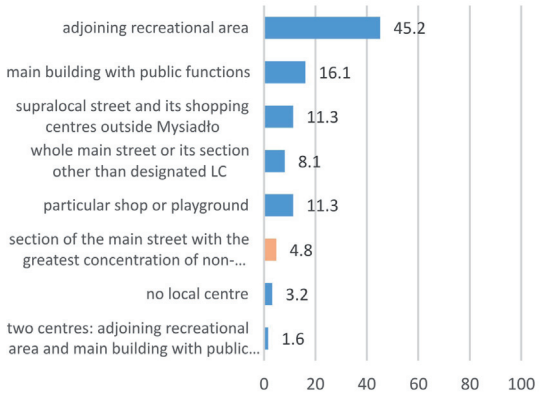
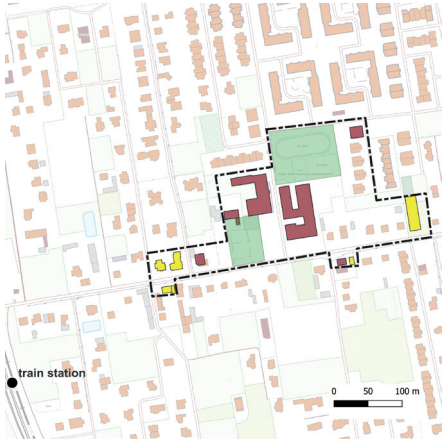
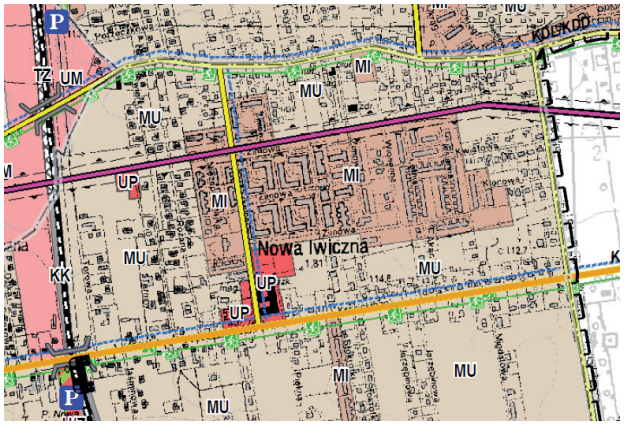
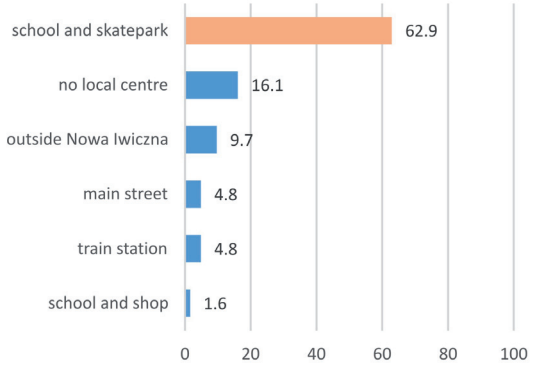
Tab. 3. Typology of suburban local centres of a neighbourhood catchment area
Source: author's elaboration

LC designated according to adopted criteria	LC designated in the spatial policy[a] of the municipality	LC indicated by the residents (%)
KOMORÓW		
		
LC with a centre-forming layout and functions, and a high social potential	Centre of the priority area with retail and service units, education services, and greenery	LC indicated by the residents consistent with the LC determined according to the adopted criteria
STARE BABICE		
		
LC based on a historical market square	No central space; service areas and residential and service areas designated	LC indicated by the residents consistent with the LC determined according to the adopted criteria

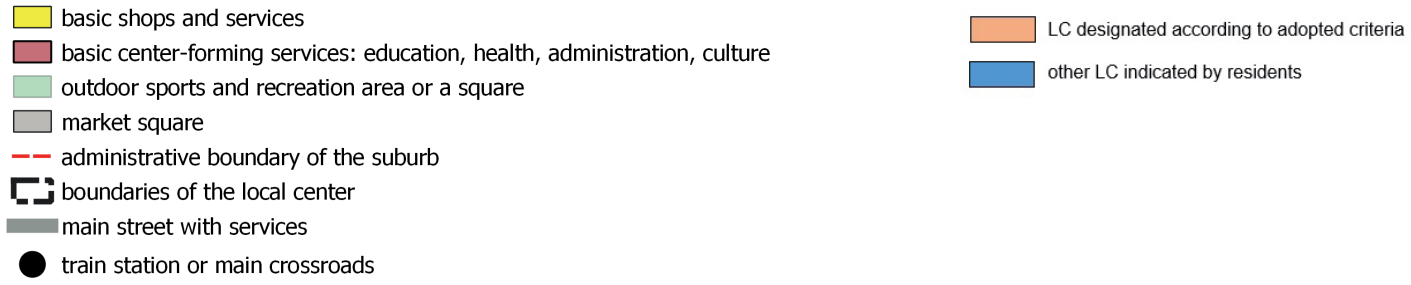
Tab. 4: Types of local centres characteristic of Warsaw suburbs – for explanations see legend on p. 203

LC designated according to adopted criteria	LC designated in the spatial policy[a] of the municipality	LC indicated by the residents (%)
	RASZYN	
		
LC based on public buildings and a newly developed market square	Centre of the municipality with areas of multifunctional development and areas of commercial services	LC indicated by the residents consistent with the LC determined according to the adopted criteria
	CHOTOMÓW	
		
Linear LC with the main section, but low social potential	Areas of the very centre of the village, areas of local public services and greenery	LC indicated by the residents partially consistent with the LC determined according to the adopted criteria

Tab. 4: Types of local centres characteristic of Warsaw suburbs – for explanations see legend on p. 203

LC designated according to adopted criteria	LC designated in the spatial policy[a] of the municipality	LC indicated by the residents (%)
	MYSIADŁO	
		
Linear LC with poor location, poor service offer and low social potential	No central space; residential areas and residential and service areas	LC indicated by the residents inconsistent with the LC determined according to the adopted criteria
	NOWA IWICZNA	
		
LC with an illegible layout and low commercial potential	No central space; public service areas	LC indicated by the residents rather consistent with the LC determined according to the adopted criteria

Tab. 4: Types of local centres characteristic of Warsaw suburbs – for explanations see legend on p. 203



Tab. 4: Types of local centres characteristic of Warsaw suburbs
Source: author's compilation

Notes: [a] Table presents maps from spatial policies of five suburban municipalities, namely: Michałowice, Stare Babice, Raszyn, Jabłonna, Lesznowola
Spatial policies retrieved from the following websites:

1. *https://bip.michalowice.pl/files/1095951643/zalacznik-nr-2-c-kierunki-rysunek-podstawowy.jpg*
2. *http://archiwum.starebabice.bip.net.pl/pliki/125506_Uchwala_Nr_326_-_zalacznik_nr_3.jpg*
3. *http://bip.raszyn.pl/?a=9288*
4. *http://www.bip.jablonna.pl/container/dokumnety/zagospodarowanie%20przestrzenne/studium%20uwarunkowan/z3a.pdf*
5. *https://lesznowola.eobip.pl/_gAllery/24/91/24911/Rysunek_nr_1.pdf*

LC	Spatial potential	BS	BC-FS	C-FS
Komorów	concentric layout with a centrally located railway station and a concentration of commercial functions as a core	13 small stores* and services, 2 pharmacies, bus stop	5 eateries, 2 recreational areas, health centre, train station, bank, post office, primary school with a sports field, senior club	secondary school with a sports field
Stare Babice	concentric layout with a historical market square and a church as a landmark, concentration of commercial functions nearby	13 small stores* and services, bus stop	4 eateries, 2 health centres, 2 municipal offices, church, park, post-office	
Raszyn	concentric layout with a market square as a newly developed core and equally important public buildings throughout the whole LC	13 small stores* and services, 2 pharmacies	4 eateries, 2 buildings of a primary school with a sports field, 2 banks, kindergarten, library, post office, municipal office, health centre, fire station, medium-sized shop	
Chotomów	linear layout with the largest crossroads as a central point, different functions scattered along the sector of the main street	4 small stores* and services, small square, bus stop	2 medium-sized shops, church, primary school with a sports field, post office, cultural centre, restaurant	
Mysiadło	linear layout with the multifunctional building as a central point, located peripherally along a sector of the main street bordering the adjacent suburb	11 small stores* and services, pharmacy, playground, bus stop	2 eateries, library, post office	
Nowa Iwiczna	scattered layout with a polycentric form of the LC's core embracing equally important educational and recreational objects, located within a quarter of streets	4 small stores* and services	3 buildings of a primary school, cultural centre, skate park, bank, medium-sized shop	

Tab. 5: Service offered by suburban local centres. Source: author's elaboration
*Notes: * Stores embrace food and industrial goods supply. BS – basic services; BC-FS – basic centre-forming services; C-FS – centre-forming services*

facilities (Nowa Iwiczna). If a transport node is too distant from the LC, it negatively affects the number of potential users and the economic vitality of the central space.

In recent years, suburban recreational areas have gained importance as a new element of the development of suburban space, especially after Poland's accession to the EU, which opened up new opportunities for financing this type of facility. Recreational areas in dispersed suburbs, especially playgrounds and local sports fields, give opportunities to gather and integrate, although they rarely attract commercial and service functions (e.g. Stare Babice, Mysiadło, Nowa Iwiczna). In the case of suburban LCs, small recreational areas have low centre-forming potential, although they significantly increase attractiveness and multi-functionality of the whole central space.

4.2 LCs indicated by the residents

In the case of a centre-forming concentric layout based on the main crossroads, a road crossing with a railway line, or a market square, accompanied by commercial and public premises, it is easiest for the residents to indicate the central space unambiguously (Komorów, Stare Babice). Compared to concentric layouts, newly built public utility buildings lacking basic services nearby, located within a random block of streets, are less frequently recognised as a local centre. Linear structures turned out to be the most problematic in this regard. The research revealed, however, that the location of a shopping centre or a larger supermarket on the periphery, on the border, or outside the suburb (Stare Babice) is one of the factors disrupting any regularities in perceiving particular structures as local centres. On the other hand, retrofitting the space by introducing a square market with centre-forming functions may reverse the tendency of perceiving large-scale commercial buildings as a LC (Raszyn).

The main centre-forming objects or facilities such as railway stations are naturally perceived as local centres. They are deemed as such even if they are located at some distance from the main concentration of commercial functions and there are no retail and service units around them (railway stations in Chotomów and Nowa Iwiczna). In the case of the underdevelopment of commercial functions, respondents more often say that there is no local centre. If the greatest concentration of trade and service is located peripherally, more residents are willing to look for a LC outside the suburb (Mysiadło).

4.3 Approach towards planning local centres

The intention to retrofit suburbs by reinforcing local centres should be outlined in the spatial policy of the municipality. In the suburban municipalities under study, however, there is quite a wide variety of approaches to planning local centres, setting their boundaries, and naming, which may be a significant obstacle in making suburbs more sustainable. Local centres are most often designated for villages of key importance for the municipality (Komorów, Chotomów) or villages that are the seat of the municipality (Raszyn), although it also happens that for the latter, spatial policy does not indicate central space (Stare Babice). For the village centres, spatial policies use different nomenclature, e.g. centre of the priority area, centre of the municipality, areas of the very centre of the village. Their boundaries are

Fig. 6: Market square with a church in Stare Babice (Photo: M. Osiak)

Fig. 7: Newly-built market square with a fountain in Raszyn (Photo: A. Kryczek)

also delineated differently. Some local centres are marked with a signature only (Komorów, Raszyn), while others are precisely delimited on a map (Chotomów). When it comes to the functions of the areas planned to be local centres, commercial services dominate along with public services.

Few municipalities emphasise the multifunctionality of such spaces (Raszyn). Some municipalities have not designated local centres in their spatial policies, also for those villages that are subject to intensive suburbanisation (urban villages such as Mysiadło, Nowa Iwiczna). Some of them have delimited only areas for public services, most often educational (Nowa Iwiczna). Such areas are perceived by the residents as local centres although commercial functions around them are underdeveloped.

In the case of suburbs originated from previous rural villages, the central space is closely related to service facilities and landmarks. For this type of suburbs, a church (or a chapel) is one of the most important objects. Apart from its sacred function, it often plays a cultural and social role. When it comes to the facilities generating social activity, they embrace also schools, public administration buildings, health centres, commercial and service premises, rural community

clubs, and fire stations. Compared to the old suburbs, new suburban settlements are deprived of such a variety of utilities and landmarks. Their local centres usually rely on a newly built school as the nucleus.

In recent years, numerous sports facilities and playgrounds have been built in both old and new suburbs (Fig. 8). Some of them are centrally located, but compared to other objects, their potential to reinforce the central space is weaker due to low social vitality (Mantey, 2019). Suburbanites, when asked about the objects that could encourage them to use local centres more often, listed outdoor mini-markets and various eateries such as bars, pizzerias, restaurants or café (Fig. 9). Retail space with fresh agricultural products and third places where local social ties are maintained (Oldenburg, 1999, 2000) seem to be the most missing and at the same time the most desirable suburban facilities. They have a high social potential to increase the vitality of suburban central spaces.

5. Discussion and conclusions

The typology of local centres presented in this report organises the previous attempts to categorise this kind of space and makes a shift towards suburbia. It helps to identify meaningful spaces that may act as local centres of a neighbourhood catchment area in different spatial arrangements of post-socialist suburbs. Although the typology has been tested in the Warsaw urban region, the premise for its wider application is the similarity of suburbanisation processes in all Central and Eastern European (CEE) countries. On the outskirts of large post-socialist cities, suburbs are growing mainly from villages, but also from small towns, pre-war garden cities, socialist suburban enclaves, and socialist recreational cabin settlements. The LC of Jesenice (Prague urban region), described by Zévl and Ouředníček (2021), seems to be representative of these types of old suburbs. The original core of the village is situated on the main road to Prague's south-eastern hinterland. In the core, there is a mixture of building designs and uses, and the ground level of buildings is frequently used for commercial purposes (restaurant, post-office, pharmacy, etc.). The polyfunctionality of this sector of the road makes it the centre of Jesenice, although it is not perceived by residents as such. According to the Strategic Plan of the town, residents miss a clear central public space (Město Jesenice, 2011, after: Zévl and Ouředníček, 2021).

Apart from the old suburbs, there are also new ones that arise as new settlements on "greenfields" (Zębik, 2011; Kubeš and Nováček, 2019; Mantey and Sudra, 2019), often in the form of leap-frogging urban sprawl. Sprawling suburbs still lack basic public facilities, local centres and infrastructure. Only in some cases, the development of commercial

Fig. 8: New park in Stare Babice (Photo: D. Mantey)

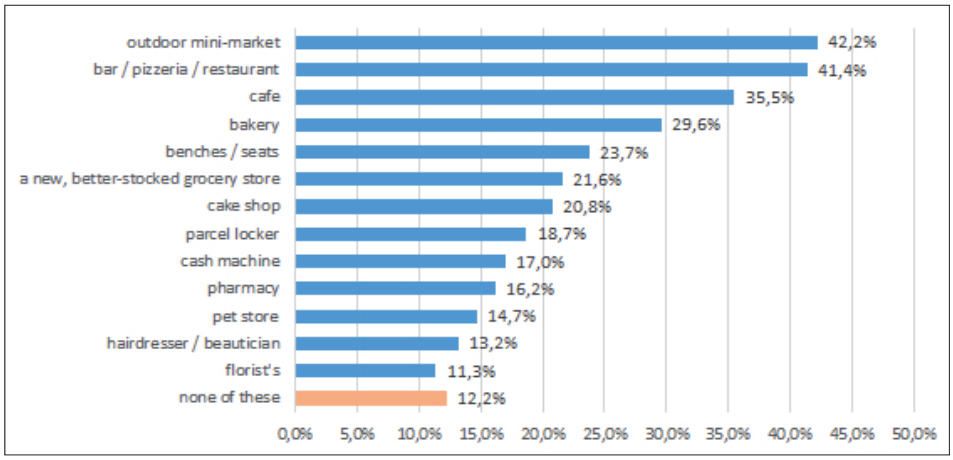


Fig. 9: New facilities and functions that would encourage suburbanites to use a local centre more often (N = 476) Source: author's elaboration

facilities has just begun along the major roads (Dinić and Mitković, 2016). The type of suburban development that has not yet taken root in this part of Europe is transit-oriented development (Zębik, 2011).

Since in all post-socialist countries similar processes are the driving forces behind suburbanisation, the spatial arrangements of individual settlement units are also somewhat comparable. Local centres are most often in the core of old suburbs. Many new neighbourhoods are deprived of nodes of social and economic activity since they are located on the edges of existing settlements, often in isolation from the original village, or as a separate small settlement unit. It is much more difficult to establish a local centre in a new suburb, not only because of the spatial disorder but also because of the lifestyle of the residents who satisfy various needs outside their place of residence. Thus, one of the biggest problems post-socialist suburbia faces nowadays is mono-functionality, most often the non-existence of any other urban use except the residential one, and poorly designed public spaces (Dinić and Mitković, 2016).

This article suggests retrofitting suburbs by strengthening local centres, which may be one of the models of suburban transformation, together with the three already existing ones:

1. Recovering the pre-existing networks (rural roads, old paths, and watercourses) recognised as strategic components for reconnecting and providing civic cohesion (Holcomb, 2008; Vall-Casas et al., 2011);
2. Recycling of dead shopping malls or commercial strips (Dunham-Jones and Williamson, 2009);
3. Recovery of metropolitan open spaces (Girling and Helphand, 1997; Platt, 2006).

Here it is suggested that a multifunctional local centre served by public transport should become the essence of a modified neighbourhood unit concept. Strengthening neighbourhood units in post-socialist Europe, however, may be problematic. This is due to common symptoms of disordered (sub)urban sprawl and poorly organised built-up areas, which is manifested in small-sized new suburban communities (the community is not large enough to have its own school), chaotic urban structure with no centre, poorly arranged streets, commerce, and industry enclaves, and intensive road traffic (Kubeš and Nováček, 2019; Zębik, 2011).

When adopting the retrofitting model based on a neighbourhood central space, breaking down mono-functionality should be a prerequisite for integrating people and their activities (Gehl, 1987). Fortunately, most of the already existing suburban LCs offer not only basic services, but also basic centre-forming services, mainly education, administration, health, sport, and recreation, less often culture. Public facilities, however, are not able to increase the economic vitality of overly dispersed suburbs with poor walking conditions.

The social potential of central space is determined not only by its functions but also by the spatial arrangement in which it is embedded. Concentric layouts attract people and different non-residential functions more effectively than linear ones, since they direct a large proportion of pedestrian traffic to one place. There is a positive correlation between higher street integration measured by closeness (how close each segment is to all other segments in the network) and a greater pedestrian volume (studies that demonstrate this correlation are mentioned by Jabbari et al., 2021). Places linked directly to other environments are more accessible and tend to attract more people, making areas busier. The very form of the concentration of services is also important. For social and community-building reasons, the market square seems to be better than the main crossroads, just as the local street is better than the supralocal road. Supralocal roads have less social potential since they are more friendly for cars than for pedestrians and serve not only local users. Unfortunately, this is where the main public transport stops are usually located, thus depriving LCs of an important function that could increase their utility. The least favourable situation for strengthening neighbourhood ties is the peripheral location of the LC within the neighbourhood, more common in the case of linear centres.

A local centre as a meaningful space is perceived by the residents through the prism of the legibility of the broader spatial arrangement. There are several spatial components that are most often noticed and remembered by the residents, including city crystallisation elements, streets, areas, border lines and strips, spatial dominants, outstanding landscape elements, nodal points, special signs (Wejchert, 1984). The lack of individual features makes the space difficult to identify, while elements crystallising the village plan affect the ease of recognising in space, moving around, and noticing places. When recognising some spaces as central, the presence of key objects with centre-forming functions is equally important. Primary schools and the accompanying sports areas are of special importance, especially in new suburbs. Apart from the objects that facilitate perceiving some spaces as central, there are also factors that distort such recognition, namely the excessive dispersion of buildings, and hence trade and service points; peripheral or random location of the main activity node or centre-forming object; poorly equipped central space; the proximity to the big-box shopping centre or large recreational area. This may explain why the market square is not always perceived as a local centre.

In search of the model of retrofitting Polish (but also other post-socialist) suburbs, it is worth focusing on shifting suburbs from settlement units dominated by anonymity into genuine neighbourhoods. Referring to the neighbourhood unit theory (Perry, 1929), it should be emphasised that neighbourhoods require more than mere geographical boundaries, they involve the fundamentally functional needs of the people therein (Park and Rogers, 2015). Suburban local centres as meaningful spaces have a chance to respond to these needs provided that they are multifunctional, safe, structured, and in walking distance from most of the houses. Such spaces have a chance to maximise the liveliness of suburban neighbourhoods. Their potential, however, can be activated when optimal spatial conditions persist. To achieve this, the process of densification of suburban settlements through infill and redevelopment strategies should be implemented into spatial policies of suburban municipalities. Although new suburbs abound with spaces enclosed between buildings that lack quality and seek new functions and identities, they cannot be reused or used for the public easily since most of the suburban space has the status of private property. Besides, suburban centres are more clusters of services within individual land parcels than fully formed public spaces, which would have the potential to integrate the scattered housing development and create new contemporary centres at a local scale (Bajwoluk, 2015).

Redevelopment strategies, therefore, should involve improving the walkability of the entire suburb and accessibility to public objects and facilities, by building

interconnected street networks that distribute traffic and reduce overall vehicle kilometres travelled. The infill approach, in turn, lies in densifying the core of the suburb by introducing public transport and localising public objects as well as recreational areas in central space. Creating or strengthening local centres can be accomplished through:

1. density, increasing in central space and reducing with distance;
2. accessibility to different key destinations (schools, bus stops, train stations, etc.) within walking distance;
3. mixed-use;
4. a transport system that prioritises not only the needs of pedestrians and cyclists but also public transport passengers (UTF, 1999; Williams, 1999).

The viability of local shops and services, and the use of public transport are negatively affected by the low density of the suburb, the insufficient population in the catchment area of the LC, and the adjacent big-box retail and service facilities. As a consequence, the potential of local centres can be significantly diminished.

In conclusion, post-socialist suburban local centres do not constitute fully formed compositional and functional structures. They include spaces with a mature urban form but poor functional offer, spaces along transportation routes but with unattractive public space, or spaces offering commercial facilities but not much else. This is partly due to diversified approaches towards planning LCs, manifested in the spatial policies of suburban municipalities. Such diversified approaches towards layouts, forms, location, and functions are recommended to be standardised, which requires top-down implementation of urban standards. In the ongoing transformation of metropolitan areas in the post-socialist CEE countries, the formation of hierarchical network of subcentres outside of the metropolitan core is also not fully articulated (Stanilov and Sýkora, 2014), although advisable.

When developing standards for suburban central spaces, however, we should take into account not only street layout and the distribution of commercial facilities, but also – and perhaps most importantly – the socio-cultural needs of the inhabitants, their lifestyle, and their ways of spending free time. When looking for a model of "centrality" for single-family housing estates, it is worth recalling the concept of the so-called "third places" by R. Oldenburg (1999, 2000). Suburbanites often prefer spaces of relaxation in public, encountering familiar faces, and making new acquaintances rather than spaces to exchange goods, services, and information (Mantey, 2015). Such needs are part of the ideal of suburban life, associated not only with a quiet and peaceful place to live but also with attractive places to spend free time. Shopping centres attracting suburban residents not only with their retail offer but also with eateries, cinemas, playrooms for children, etc., are the worst scenario for the social life of post-socialist suburbs and together with the lack of planning of local centres, one of the most serious inhibitors of the retrofitting process.

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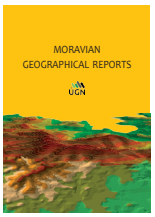

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A GIS-based framework to determine spatially explicit priority categories for flood risk management intervention schemes

Adrienne ORTMANN-AJKAI [a *], Tamás MORVA [b], Ervin PIRKHOFFER [b], Dénes LÓCZY [b], Ákos HALMAI [b], Gergő NÉMETH [c], Péter GYENIZSE [b]

Abstract

The necessity of plural valuation of costs for flood risk management is widely acknowledged, but practical case studies are still scarce. We developed a GIS-based plural valuation framework to determine spatially explicit priority categories for flood risk management intervention schemes on the Drava River, Southern Hungary. A conventional economic evaluation, including land market prices and additional costs due to legal conservation restrictions, was complemented by ecological valuation of vulnerability. The inclusion of ecological vulnerability significantly changed the proposed priority areas for flood risk management interventions: in this case, softwood riparian forests face far less threat, together with other Natura 2000 habitats, in comparison to unprotected wetlands and grasslands. This valuation framework also highlights priority habitats and areas for joint conservation and water management projects, utilising the synergies between several EU Directives as the Birds Directive, Habitats Directive, Flood Directive, and Water Framework Directive. Our framework is adaptable for the other floodplains along major or medium-sized European rivers, assuming that specific local settings are considered.

Keywords: *plural valuation framework; decision support system; ecological vulnerability; riparian forests; wetlands; Water Framework Directive; Hungary*

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1. Introduction

Water resource management aims to secure numerous and varying ecosystem services of wetlands, floodplains, and watersheds, as supplying water for household use, agriculture, industry, heating and cooling, hydropower, transport, and also for leisure; see European Environmental Agency (hereinafter EEA) (2018).

The emerging concept of integrated water resource management reflects the need to harmonise the provision of hydrologic services with the obligations of several Community Directives. The aim of the Water Framework Directive (hereinafter WFD) is the protection of all surface waters and groundwater and to achieve good status in all waters, through the protection of aquatic habitats and generally water resources; see European Council (hereinafter EC) (2000). The 'Birds' and the 'Habitats' Directives (hereinafter BHD) together form the backbone of the EU's biodiversity policy as they protect Europe's most precious species and habitats. These ecologically valuable areas form the Natura 2000 network, which includes the majority of national parks and legally protected areas in Hungary. The objectives of the directives are interrelated, and special attention and coordination are needed where these directives are implemented in the same areas (EC, 2011).

The Flood Directive (EC, 2007), launched as a response to the devastating floods in the first decade of the 21st century, which recurred in the second and third decades (Schindler et al., 2016; CEDIM, 2021), regulates the assessment and management of flood risk. Along with the River Basin Management Plans (hereinafter RBMP), Flood

[a] Institute of Biology, University of Pécs, Pécs, Hungary (*corresponding author: A. Ortmann-Ajkai, e-mail: *aadrienn@gamma.ttk.pte.hu*)

[b] Institute of Geography, University of Pécs, Pécs, Hungary

[c] Doctoral School of Earth Sciences, University of Pécs, Pécs, Hungary

Risk Management Plans (hereinafter FRMPs) have been prepared. Flood Risk Management (hereinafter FRM), like river basin management, acts at the landscape level, influencing the existence and living conditions of large human and non-human populations, and also of other components of landscapes, such as natural habitats, aesthetic, cultural, and intrinsic values, together with the ecosystem services (hereinafter ES) provided by them. It creates and maintains safe shipping ways by shortening and straightening the river course (cutting off meanders). Furthermore, it employs dikes to protect agricultural areas and human settlements from flooding. At the same time, FRM interventions also have negative effects on other floodplain ESs. They may lead to riverbed incision and floodplain desiccations, thus weakening their biodiversity conservation (habitat maintenance) potential, which is perhaps the most often mentioned ESs of floodplains (Blackwell and Pilgrim, 2011; Haines-Young and Potschin, 2013). The intervention of FRM may also damage aesthetic, cultural, and intrinsic values temporarily or even irreversibly.

According to FRMPs, most European countries have designated flood retention areas to manage flood events and to avoid unsuitable land uses. Flood retention areas are usually situated in the lower-lying parts of active floodplains, where high wetland biodiversity is preserved under less intensive land-use; consequently, they often overlap with nature conservation areas within the Natura 2000 network (EEA, 2016). They host a wide array of habitats of community interest and their rich flora and fauna. Large parts of floodplains are parts of the Natura 2000 network (EEA, 2016), and protected also by national conservation legislation, often as national parks. To fulfil all legal obligations, even to resolve their contradictions, flood risk management (FRM) interventions have to be harmonised with the WFD and Birds and Habitats Directive.

Furthermore, FRM has to build consensus among all stakeholders to secure the interests of land users, as interventions, especially if they involve economically valuable areas such as arable lands, often cause immediate or delayed economic damage to landowners. Whether this impact is easily mitigated, or causes long-lasting damage, depends on many factors, e.g. on the type and area of the intervention, on the method of rehabilitation (if any), and on the landscape context (e.g. habitat types, or invasion routes of invasive alien species).

Monetary valuation techniques of ESs are increasingly widespread and accepted. A range of practical methods are developed and tested, and numerous case studies are published, including those from floodplains and wetlands (e.g. Meyer et al., 2012; Pinke et al., 2018). At the same time, it is to be remembered that monetary valuation only represents one component of ES valuations (Boeraeve et al., 2015), and monetary and non-monetary approaches should equally be applied (EC, 2012). To consider the full diversity and complexity of ESs in decision-making, a scientifically well-founded plural valuation of costs and benefits is indispensable, and the number of such studies in this field are increasing (Jacobs et al., 2016). Plural valuation, proposed by several authors, is more relevant for practical use if it is embedded in local settings (Meyer et al., 2009; Pinke et al., 2018).

Our framework is innovative in that it extends the above-discussed conventional valuation framework to include ecological aspects. For this extension the concept of ecosystem vulnerability is chosen. Ecosystem vulnerability, besides resistance and resilience, is one of the key issues in ecosystem ecology. It is considered as a potentially useful measure in risk assessment and management (de Lange et al., 2010), especially in the case of wetland habitats (Weisshuhn et al., 2018). Ecological or ecosystem vulnerability "is an estimate of the inability of an ecosystem to tolerate stressors over space and time", and it is determined by the characteristics of the ecosystem (Williams and Kaputska, 2000), e.g. a certain habitat type. The application of the vulnerability concept to ecosystems is still an emerging topic (Weisshuhn et al., 2018), such that the development of general indicators is an open question at this time. Beroya-Eitner (2016) expressed the opinion that …"ecological vulnerability assessment and the development of indicators … should be conducted at smaller scales and must be context-specific". A categorical system, based on local expert judgment may be an appropriate tool for a robust evaluation, and a further advantage is the use of state-of-the-art knowledge and local expertise (De Lange et al., 2010).

According to the recent review by Weisshuhn et al. (2018), vulnerability to invasive species is a preferred topic in vulnerability studies. Ecological vulnerability can be assessed through biological invasion, as the presence and abundance of invasive alien species (hereinafter IAS) are regarded a good indicator of the local deterioration caused by many types of FRMs (Janssen et al., 2016). Invasive alien species are considered as one of the main conservation challenges, second only to habitat loss (Rabitsch et al., 2012), both globally (Mölder and Schneider, 2011), and also for Europe (Maes et al., 2014; Schindler et al., 2016). The presence of IAS is used as an indicator of recent global biodiversity decline (Butchart et al., 2010); and is also one of the European biodiversity indicators (Rabitsch, 2012). IAS are considered as threats at the river-basin or floodplain scale (Apostolaki et al., 2019; Ortmann-Ajkai et al., 2018).

River valleys are particularly vulnerable to biological invasions (Dyderski and Jagodzinski, 2016). Disturbance increases invasibility (Stanković et al., 2019). Regular floods destroy or damage large parts of the riparian vegetation, creating suitable habitats for the colonisation by different species, of which IAS are the most successful ones due to their outstanding competitiveness (Pyšek and Prach, 1993). Rivers may act as dispersal agents transporting downstream propagules of IAS (Aguiar and Ferreira, 2013). Wetlands are especially endangered by IAS, as neophytes have a stronger affinity to wet habitats and disturbed woody vegetation, while archaeophytes tend to be more common in dry to mesic open habitats (Chytrý et al., 2008). In Europe, warm lowlands as the Po and the Danube basins (where our study area is situated), are the most invaded areas (Chytrý et al., 2009).

To balance all aspects and interests, the multifunctional floodplain management concept (Schindler et al., 2016), landscape function classification (Stejskalová et al., 2012) and the ecosystem service approach (Maes et al., 2014, Grizetti et al., 2016) are suggested as tools to aid decision makers in finding more sustainable solutions. Monetary valuation techniques of ESs are increasingly widespread and accepted. A range of practical methods are developed and tested and numerous case studies are published, including those from floodplains and wetlands (e.g. Meyer et al., 2012, Pinke et al., 2018). At the same time, it is to be remembered that monetary valuation only represents one component of ES valuations (Boeraeve et al., 2015), monetary and non-monetary approaches should equally be applied (EC, 2012). To consider the full diversity and complexity of ESs in decision

making, a scientifically well-founded plural valuation of costs and benefits is indispensable, and the number of such studies are increasing (Jacobs et al., 2016). Plural valuation, proposed by several authors, is more relevant for practical use if it is embedded in local settings (Meyer et al., 2009; Pinke et al., 2018).

Nevertheless, few studies apply plural valuation at the local scale, relevant to decision making (e.g. Stejskalová et al., 2012, Pandeya et al., 2016). Our study fits into this research gap. Its main goal is to provide a plural valuation framework for supporting science-based decision-making during the planning process of FRM interventions. This framework consists of two parts. First, an economy-based approach is presented; then it is extended to include the non-monetary costs of risk to threatened habitat types of European importance.

2. Study area and methods

2.1 Study area

2.1.1 Physical features

Our study area is located on the floodplain of the Drava River. The Drava drains waters from the south-eastern Alps. It originates at the western end of the Karnian Alps, South-Tyrol (Italy), at 1,192 m elevation. Its length is 896 km, its total drainage area is 43,238 km^2. Its largest tributary is the Mura, which flows into the Drava from the left side, between 236.0 and 237.0 river km. The Drava water regime is controlled by the alpine headwaters (Schwarz, 2017). Highest discharges occur between May and July. Another discharge peak in autumn is due to the Mediterranean precipitation pattern in the middle and lower courses of the river. Long-term mean discharge on the Lower Drava is 526 m^3/s with absolute minimum around 70 m^3/s and maximum of 850 m^3/s at high water. The discharge for the 10-year flood is about 2,100 m^3/s and for the 100-year flood about 3,200 m^3/s.

Since the beginning of water regulations (mid-18th century), it has been affected by human activities of various kinds and extent. Consequently, the river channel and, in parallel, groundwater levels are sinking continuously since the regulations, due to channel incision (Lóczy et al., 2017), which is disadvantageous for the riparian vegetation as demonstrated by Škarpich et al. (2016), for the conditions of Natura 2000 habitats along the river.

The area of the present study is situated in the Lower Drava active floodplain, from the Mura confluence down to Drávaszabolcs village, where the Drava leaves the country (Fig. 1). For most of its length the river forms the national border between Hungary and Croatia. The area of the active floodplain in this section amounts to 297 km^2. According to its geography, administrative and hydrology management, it consists of two sections. From 236.0 to 140.0 river km there are high banks on the left, Hungarian bank, so there are fewer flood protection dikes. The active floodplain extends over both Hungarian and Croatian territory. The second subsection lies between 140.0–70.2 river km, where the active floodplain is bordered by flood protection dikes on the lower left bank. As the whole study area is situated in the active floodplain, its role is water retention, but in case of extremely high-water levels, floods can be even devastating. As the Drava River is mainly influenced by snowmelt in the Alps, it is hazardous that as global warming and climatic extremes continue to occur, very high flood events are not to be excluded. Consequently, there is a need to invest in water management at least in the larger rivers. There were some larger floods (above 2,000 m^3/s) in the 1970s, and again in 2014 (DDVIZIG, 2020).

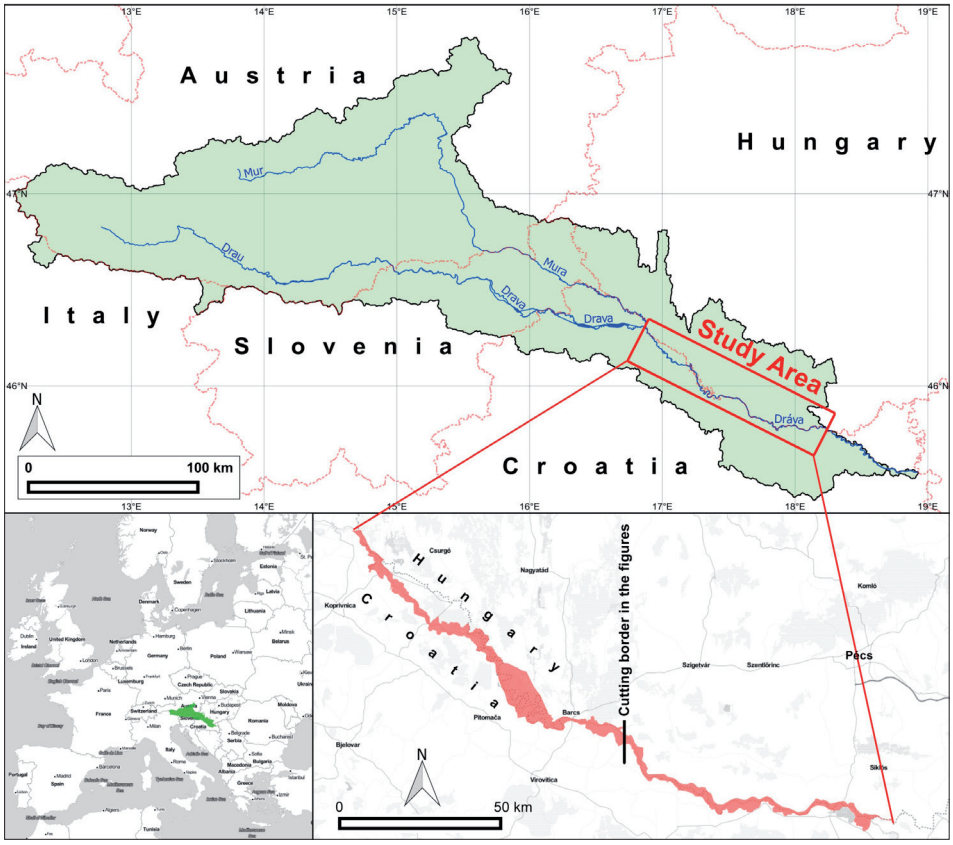

Fig. 1: Overview map of the study area. Source: authors' elaboration

2.1.2 Land-use, habitats and conservation

Among the medium-sized rivers of Europe, the Drava stands out in its naturalness. In its active floodplain, more or less regularly flooded every year, a rich array of more or less undisturbed wetland habitats are present (Kevey, 2018; Ortmann-Ajkai et al., 2018a). The majority of the habitats are of European importance (for codes see Tab. 1). Typical are the small backwaters with rich euhydrophyte and riparian vegetation; pioneer mud vegetation of temporarily drawing-out surfaces; reedbeds, sedge beds and wet meadows; and close-to-nature alluvial forests. Land uses are dominated by forestry, and to a slightly lesser extent by arable fields. Most of the woody vegetation are willow and poplar forests, oak-ash-elm hardwood forests, and to a smaller extent stands of invasive tree species (*Acer negundo*, *Robinia pseudoacacia*) are also present.

The study area represents an uninterrupted chain of habitats of community significance (Natura 2000 areas, EC 1996, Natura 2000 Network Viewer). It is a European green corridor (the UNESCO Transboundary Biosphere Reserve Mura-Drava-Danube). The Hungarian part belongs almost entirely to the Danube-Drava National Park, to the core area of the Hungarian National Ecological Network, and other NATURA 2000 areas.

2.2 Preparation of the target-oriented base map

A detailed land cover map of the Lower Drava region had not been available before our investigations started. To prepare such a map, data were collected from various sources:

- CORINE Land Cover 2018 (https://land.copernicus.eu)
- Danube-Drava National Park (http://www.ddnp.hu/)
- Hungarian Forestry Web Map (2019): (https://erdoterkep.nebih.gov.hu)
- Hungarian Nature Conservation Information system (2019) (http://web.okir.hu/map/?config=TIR&lang=hu)
- Natura 2000 Network Viewer (2019) (https://natura2000.eea.europa.eu/)
- Nature conservation base maps of Croatia (Ministarstvo gospodarstva I odrzivog razvoja, 2019) (https://www.bioportal.hr/gis/)
- Sentinel-2 database (2019) (https://scihub.copernicus.eu)
- UNESCO (2019): (https://natura2000.eea.europa.eu/ (http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/europe-north-america/croatiahungary/mura-drava-danube/)

Habitat name	EUNIS code	Natura 2000 code	Extension (km^2)	Spatial pattern
Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	C1	3150	43.92	common
Natural dystrophic lakes and ponds	C1	3160	negligible	small and very rare stands
Rivers with muddy banks with Chenopodium rubri p.p. and Bidention p.p. vegetation	D5	3270	negligible	small temporal stands
Alluvial meadows of river valleys and lowland hay meadows[1]	E2, E3	6440	21.96	patches of varying size
Alluvial forests with *Alnus glutinosa* and *Fraxinus angustifolia*[2]	G1	91E0	106.70	Large stands, dominant habitat type of the study area
Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *U. minor*, *Fraxinus excelsior* or *F.angustifolia* along great rivers	G1	91F0	21.96	large stands

Tab. 1: Natura 2000 habitats and their distribution in the study area (Notes: [1]distinguishable only in the field; [2]Natura 2000 priority habitat). Source: authors' compilation

The land-use classes, which are clearly identifiable from aerial photographs, were manually digitised: built-up area; industrial-commercial area; arable land; pasture, meadow, bush and transitional wood; water surface. The rest of the area was classified using satellite image analysis: close-to-natural hardwood forest (oak, ash, hornbeam etc.); close-to-natural softwood forest (poplar, willow, alder); pinewood; alien tree plantations (primarily black locust and red oak); waterlogged areas. The bands of 3, 4 and 8 of Sentinel-2 Level 2A satellite images of high resolution taken in spring, summer and autumn were classified in ArcGIS Pro environment.

First, the land cover classes identified from Sentinel-2A satellite images were checked using control sites, selected in forest districts of the official Hungarian forest map website. The pixels of control sites were correctly classified to 75–96% by the Support Vector Machine algorithm.

First interpretations revealed that the data of this website are rather generalised, i.e. mostly show only the tree species predominant in the given management unit. Therefore, at the stage of identifying training areas as well as during later checking, the aerial and satellite images were also analysed by a biologist expert for colours, patterns, objects etc., similar to the method of compiling the high-resolution ecosystem map for Hungary (Tanács et al., 2021), or other publications, e.g. Demková and Lipský (2017). It was especially useful in the case of pastures (complex grassland-shrubland patterns) and old-growth softwood riparian forests with non-continuous canopy. For the resulting habitat types and map see Figure 2.

For the "Legal protection" layer of the base map, mapped habitat units were grouped according to legal conservation categories as national parks areas, Natura 2000 areas (outside NPs) and areas without conservational restrictions.

2.3 Development of the plural valuation method

For the robust estimation of monetary costs, which determine the priority ranking of areas to be used for intervention of FRM measures on specific sites, a category-based evaluation procedure was developed. Land-use types were classified according three factors into categories by land price, by legal protection and by ecological vulnerability.

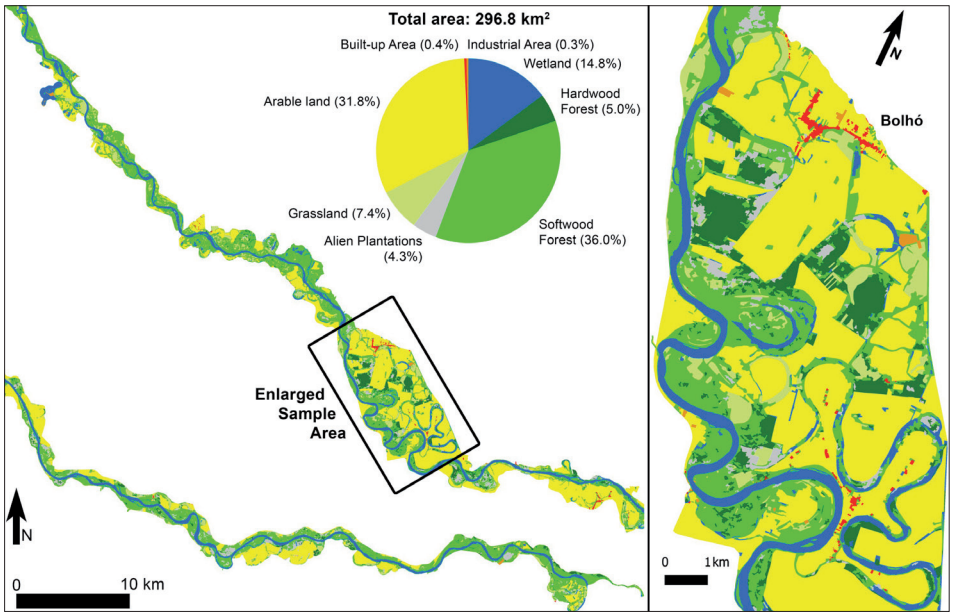

Fig. 2: Habitat map of the study area
Source: authors' elaboration

For land price categories, land prices were determined by the market price method (Meyer et al., 2012) for each land-use type. Sites for FRMs (e.g. dike or canal construction) or water retention are usually expropriated for this purpose, or landowners must be compensated, as they may suffer immediate or delayed economic damage. In the first step, land prices were collected from national databases (AGROINFORM (2019), KSH (2019), with dimensions as EUR/ha and EUR/m^3. HUF prices were exchanged to EUR at the rate 1 EUR = 325 HUF, central parity for EUR/HUF by the Hungarian National Bank for the year 2019 (Hungarian National Bank 2019). In the second step, relative weights were calculated in the following way. For the relative land weights, EUR/ha prices for arable lands, grasslands and forests were averaged; relative weights were defined as percentage values of this average (dimensionless). For wetlands no adequate price database were found. As they are usually regarded as economically useless areas, not appropriate for profitable cultivation, their value was defined empirically as "low". In the case of forests, land prices were further differentiated because softwood and hardwood (including aliens) timber prices are different. Refinement was made by multiplying this value with the value of relative timber weights. Relative timber weights were calculated according to the above-mentioned logic: EUR/m^3 stumpage prices were averaged and relative weights were defined as percentage values of this average (dimensionless). Market prices of different timber types were obtained from the website of the regional forestry management (Mecsekerdő, 2019).

Land price categories were defined by dividing the range of relative land weights (from 0.66 for grasslands to 1.55 for arable lands) to three equal intervals of 0.316, so category A included land types between 0.6–0.92, category B: 0.93–1.21, category C: 1.24–1.55. Therefore, areas in Category A are eligible as priority areas for the intervention of FRM measures; areas in Category C are the least recommended for this purpose. The planning of FRM intervention includes authorising procedures. In areas, where the level of legal conservational protection is higher, there are more legal restrictions and obligations, authorisations is more cost- and time-intensive (Tab. 2). For comparability with other variables, three legal conservation categories were established. Category A includes areas without legal protection, where there is no need for permissions from conservational authorities when changing the mode of cultivation or property changes. Category B includes Natura 2000 areas. Their legal protection level is lower than that of legally protected National Park areas, but certain changes in land use or cultivation modes needs permission of the conservational authority. Category C includes areas with a National Park status. National Parks fall within the scope of stricter legal regulations, where most changes of land use or cultivation modes require permission of the conservational authority. Similar to land price categories, areas in Category A are proposed to be priority areas for the intervention of FRM measures.

Land price and protection are aspects regarded conventionally in water management decision making. For this reason, the next step is to merge these two pillars into the cost – protection category system (PP), which eventually defines the priority order, if only economic aspects are considered. The method of merging is applied to preserve the lower priority rank, i.e. A for merging A and B; also, A for merging A and C (see Tab. 5, Columns 1, 2 and 4). Modifications in industrial-commercial and built-up areas would directly affect the everyday life and work of the human population and structures of traffic and border security (the Drava River here is the state border between Hungary and Croatia, i.e. the external border of the Schengen area). Changes in such areas have to be avoided, so they were excluded from further analysis. As for the Croatian part, there were no data available, so the same categories were applied there too.

The innovation of our framework stands in extending the above-discussed system to include ecology aspects. For this extension we employed ecosystem vulnerability, which can be assessed through biological invasion. Our assessment fulfils three of the four criteria formulated by de Lange et al. (2010): it is based on expert judgment (field experiences, and a rich array of literary sources); includes knowledge of certain stakeholders (landowners, conservation personnel); results are ranked categories and mapped.

Subject of permission	Categories		
	A	B	C
Selling of land	x	x	x
Changing the way of cultivation	x	x	x
Cutting or planting trees outside of forests	–	x	x
Ploughing or sowing of grasslands, or creating tree plantations on them	–	x	x
Cutting reeds, removing aquatic vegetation	–	x	x
Tree cutting in forests during the vegetation period	–	–	x
Grazing or mowing of grasslands	–	–	x
Burning grasslands, reed beds, abandoned arable fields, hay; fire lighting in forests	–	–	x
Use of pesticides, herbicides and other bio-regulators and fertilizers	–	–	x
Vehicle transport	–	–	x
Activities needed for maintenance and management of public roads, railways and energy networks	–	–	x
Entering strictly protected areas	–	–	x
Performing research, experiments, and collection	-	-	x

Tab. 2: Activities subject to authorisation in different legal conservation categories
Source: authors' compilation

The classification of habitats by vulnerability is in line with region-specific Hungarian and international studies. According to an overview of the invadedness of habitat types in Hungary (Botta-Dukát, 2008), riverine woodlands are most severely threatened, marshes and meadows are threatened to a lesser extent, and euhydrophyte habitats are least threatened. Stanković et al. (2019) in their ranking of southern Pannonian Ramsar sites, for the invasibility of wetland habitats, found riparian woodlands the most invasible, with medium invasibility for wet meadows, wetlands with sedge and reed beds and mesic oak-ash-elm mixed forests. Riparian softwood groves are the most threatened according to several sources including Wagner et al. (2017), Lapin et al., (2019), Stanković et al., (2019). Closed (hardwood floodplain) forests are more resistant but not quite resistant to invasion (Chytrý et al., 2009). For comparability with the land price and legal conservation categorisations, three vulnerability categories were distinguished, relying on the above-mentioned sources.

Vulnerability categories were merged with "price and protection" (PP) categories, so PPV categories emerged. This categorisation includes land price, legal protection and ecological vulnerability each. Priority rankings based on PP and on PPV categories (Tab. 5) were compared by Spearman's non-parametric correlation coefficient (Spearman's D), calculated with PAST (Hammer et al., 2001).

3. Results

3.1 Habitats of the study area

The map of habitats of the study region is displayed in Figure 2. The predominant land use type (37.1%) in the study area is riparian softwood forest, a priority habitat of community importance (EUNIS: G1, Natura 2000: 91E0). Like other riparian habitats, they are naturally disturbed due to regular inundation. Dominant tree species are white willow (*Salix alba*) and white poplar (*Populus alba*). Other common tree species are black poplar (*Populus nigra*), sometimes with a trunk diameter above 1 m (see photos in Appendix); *Ulmus laevis* and *Populus tremula*. At this elevation plantations of hybrids and cultivars of poplars (*Populus* × *euramericana* agg.), and willow cultivar plantations are common. Homogenous plantations of *Populus* clones are characteristic in the area, and they are routinely planned in abandoned meadows and for recultivation of areas destroyed by construction. As the herb layer of such plantations is usually like that of close-to-natural habitats, they also can be included in this habitat category, although their conservational value is lower compared to natural poplar stands. Their vulnerability to IAS is also similar.

Riparian hardwood forests cover 5.0% of the study area, in more extensive stands. They also represent a priority habitat of community importance (EUNIS: G1, Natura 2000: 91F0). They are situated on higher elevations of the floodplain. Before river regulations, the natural water regime of the oak-ash-elm forests included some weeks of spring inundation. Presently, as only the deepest parts (former riverbeds) are inundated irregularly, these forests can exist because of the high groundwater table. Dominant tree species are *Fraxinus angustifolia* and *Quercus robur* in varying proportions. The main common natural tree species are: *Ulmus laevis*, *Populus alba*. In the herb layer, hydrophilic species, as *Carex remota*, *Cerastium sylvaticum*, *Impatiens noli-tangere* are driven back by mesophilic ones (e.g. *Galium odoratum*, *Carex sylvatica*, *Veronica montana*, *Galeobdolon luteum*) due to the dropping groundwater level. Woody IAS are less common. Grasslands, meadows, and transitional shrubs are considered as a mosaic habitat type. In the study area, grasslands, mainly wet meadows, cover 7.4%. Some of them are utilised as pastures or mown meadows; others are abandoned with spreading shrub cover. The main utilisation of grasslands in the study area is grazing with different intensity. Therefore, there is a constantly changing pattern of shrubs and open grasslands, so these two land-use types – although they could be delineated on remote-sensed images, but just for the given date – were not differentiated in the analysis. Although these grasslands are representatives of Natura 2000 habitats (E3/6440: Alluvial meadows of river valleys; E2/6510: lowland hay meadows with *Alopecurus pratensis* and *Sanguisorba officinalis*), both overgrazing and abandonment lead to their degradation. Unless the groundwater level is high, wet meadows slowly turn into degraded drier grassland types with lower biomass production.

Open waters and wetlands cover 14.8%. Here the open water surfaces of the river Drava and oxbow lakes, and their connected reed and sedge beds are found. The aquatic vegetation of oxbows (C1/3150: small natural eutrophic lakes) consists of Magnopotamion and Hydrocharition species, as *Hydrocharis morsus-ranae*, *Lemna species*, *Salvinia natans*, *Nuphar lutea*; rarely of *Nymphaea alba*, *Nymphoides peltata* and *Utricularia vulgaris*. *Elodea canadensis* is an IAS which is present everywhere and often monodominant. High emergent vegetation (EUNIS: C5) consists mainly of *Phragmites australis*, to a lesser extent of *Typha latifolia*, *T. angustifolia*, and *Glyceria maxima* in sites of permanent water cover. In sites desiccating for some months of each year, stands of *Carex riparia* and *C. acutiformis* occur. Alien tree plantations, mainly *Robinia pseudoacacia*, less frequently *Quercus rubra* and *Pinus sylvestris* plantations on the higher, hardwood forest level; and spontaneous *Acer negundo* stands on the softwood forest level cover 4.3%. The main type of agricultural land-use are arable fields (EUNIS I1, lesser extent I2) 31.8%. Built-up and industrial areas (EUNIS J) are negligible, under 1% (0.7).

3.2 Land prices and legal protection

Land prices were calculated by the market price method, based on national and regional market databases. The average market price of grasslands, forests and arable lands and the calculated relative land weights are shown in Table 3. For wetlands, there were no generally applicable data, but as their economic value is usually low, so they were put into category A. The average timber price was 51 EUR/m^3, for softwoods (willow, poplar, alder) 39 EUR/m^3; for hardwoods (natives: oak, ash; main alien: black locust) 70 EUR/m^3; with relative timber weights, see Table 3. Finally, land use types were categorised as "low price" (A), so priority for FRM interventions: wetlands, grasslands, and softwood forests (58.2%); "medium price" (B): near-natural hardwood forests and alien tree plantations (9.3%); "high price": arable lands (31.8%): they should be avoided by FRM interventions as far as possible because of economic reasons (Fig. 3).

More than the half of the study area (58.1%), including the entire Croatian territory, is qualified as Natura 2000

	Grasslands	Forests	Arable lands		Native softwoods	Native hardwoods / Alien planted trees
Market price (EUR/ha)	1,780	2,108	4,156	Market price (EUR/m^3)	39	70
Relative weights	0.66	0.79	1.55		0.77	1.38
Land price categories						
Wetlands: „low"	No adequate quantitative data			low		A
Grasslands: 0.66	No further refinement			0.66		A
Forests: 0.79	Near-natural softwood forests: 0.77			0.79 × 0.77 = 0,60		A
	Alien plantations: 1.38			0.79 × 1.38 = 1.09		B
	Near-natural hardwood forests: 1.38			0.79 × 1.38 = 1.09		B
Arable lands: 1.55	No further refinement			1.55		C

Tab. 3: Calculation of land price categories
Source: authors' compilation

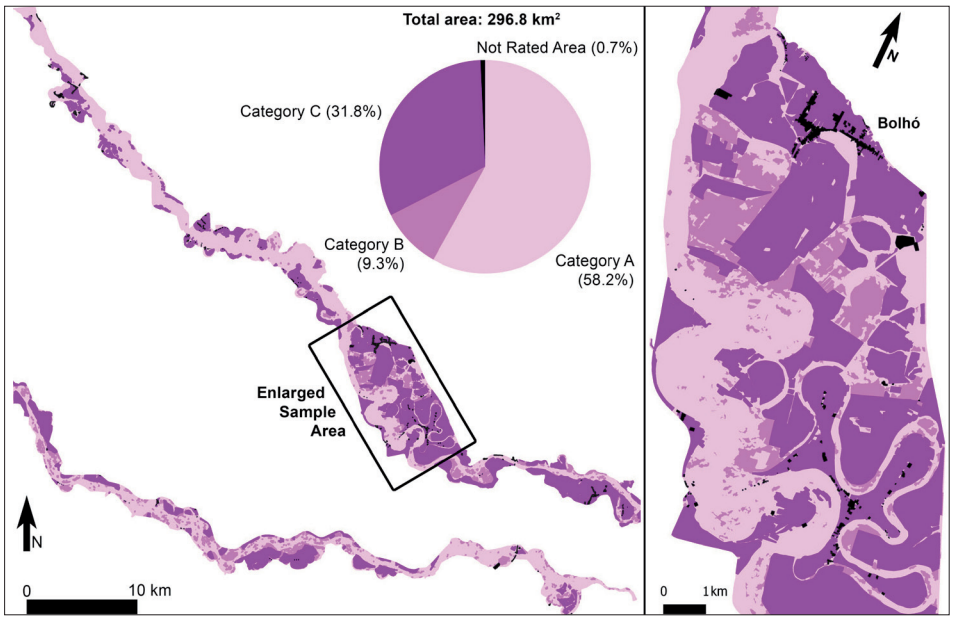

Fig. 3: Land price category map of the study area (Category A: low price; Category B: medium price; Category C: high price). Source: authors' elaboration

area. 30.5% of it belongs to the Danube-Drava National Park in Hungary, only 9.3% is without any kind of legal protection (Fig. 4).

3.3 Reconsidering priority ranks after regarding ecological vulnerability

Based on previous knowledge, and for comparability with the other two aspects, three vulnerability categories were established (Tab. 4). 36.0% of the study area is extremely vulnerable (Category C). It is covered by riparian softwood forests, and all our sources agree that they are the primary target areas of alien plant invasions. Category B extends to 27.2%, it includes near-natural wetlands, grasslands, and closed hardwood riparian forests. Near-natural wetland habitats, mainly reed- and sedge-beds in the riparian zone of small waterbodies, are moderately vulnerable. Their invasibility depends on their naturalness and/or their water supply. With good water supply, they are resistant to alien plant invasion; but degraded, desiccating stands are among the most intensively invaded habitat types. Grasslands are moderately vulnerable because their utilisation (grazing, mowing) effectively prevents the mass spreading of IAS; but if abandoned they often get invaded. Closed hardwood floodplain forest, if in good naturalness state, are also resistant to invasion, due their closed canopy. Nevertheless, if their naturalness is decreased (e.g. because of desiccation, or inappropriate forest management), they are quickly and easily invaded. Not vulnerable habitats (Category A, 36.1%) are arable lands and tree plantations (Fig. 5). FRMs implemented in arable lands will not increase invasion threats because cultivation prevents the establishment of woody IAS. Invasive tree stands are naturally regarded as not endangered, as they often consist of IAS, as e.g. *Robinia pseudoacacia*.

The comparison of priority ranks in cases when ecological vulnerability is disregarded (PP categories) *vs* regarded (PPV categories) are to be seen in Table 5 and Figure 6.

There is no change in 75.7% of the study area; but in 67 hectares (22.7%) the decision on FRM must be reconsidered: there are several reasons which make these areas less appropriate for intervention. The two lists of ranks proved to be significantly different according to Spearman's (non-parametric) rank-order correlation coefficient (Spearman's rs p(uncorr) = 0.00033). Looking at the differences on the habitat level, there is a clear division between the habitats proposed *versus* not proposed for FRM interventions. Regarding only land prices and protection regulation, not protected wetlands, grasslands, and softwood forests were ranked as priority areas. After completing the framework with ecological vulnerability, FRMs are strongly contraindicated in all near-natural habitat types, also in unprotected areas, they are proposed to be relocated into more human-affected habitats such as invasive tree stands and arable lands.

4. Discussion and conclusions

4.1 Ecology issues

There is an expressed need for the plural valuation of effects of water management interventions. Plural valuation must include, besides monetary valuation, an ecological one. Nevertheless, there are few studies, especially of local, practice-oriented investigations, which deal with this issue. Our results showed that integrating the non-monetary cost of risk to Natura 2000 habitats significantly altered the proposed priority ranking of areas for FRM interventions.

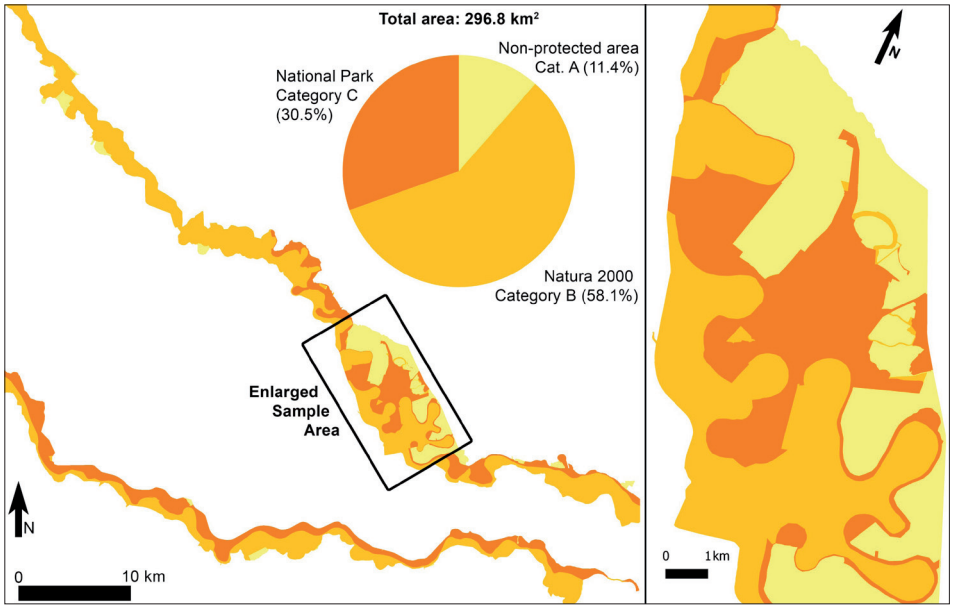

Fig. 4: Legal protection category map of the study area. Source: authors' elaboration

Category name	Category code	Habitats included
Not vulnerable	A	arable lands, alien tree plantations
Moderately vulnerable	B	wetlands, grasslands, closed hardwood riparian forests
Extremely vulnerable	C	riparian softwood forests

Tab. 4: Vulnerability categories with included habitats
Source: authors' compilation

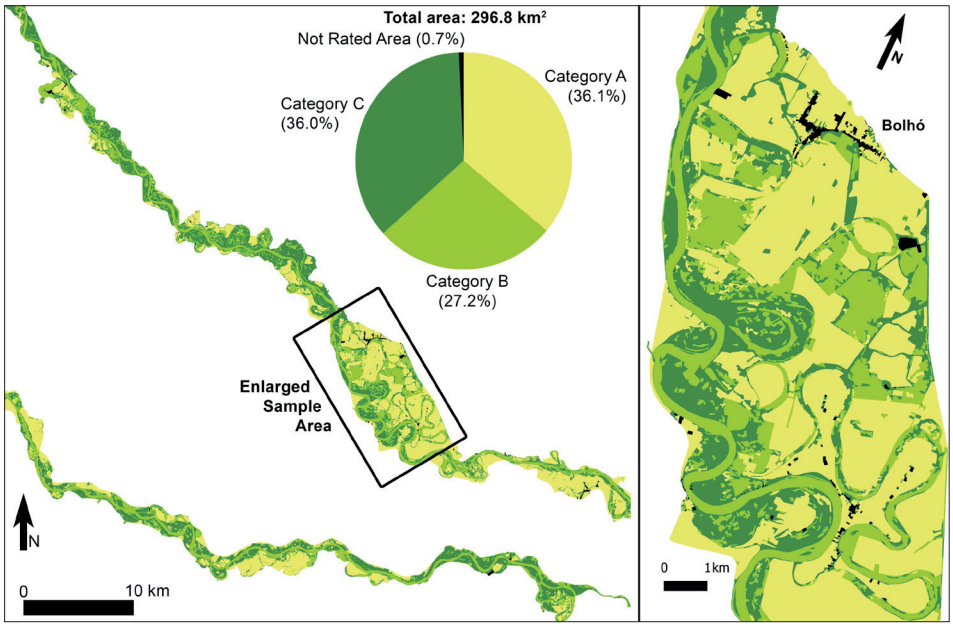

Fig. 5: Vulnerability map of the study area (Category A: not threatened by invasion; Category B: moderately vulnerable to invasion; Category C: extremely vulnerable to invasion)
Source: authors' elaboration

Habitat type	Land price	Protection	Vulnerability	Price and protection (PP)	Vulnerability included (PPV)	Category change
Near-natural wetlands unprotected	A	A	B	A	B	A to B
Near-natural wetlands in Natura 2000 areas	A	B	B	B	B	
Near-natural wetlands in National Park	A	C	B	C	C	
Hardwood forests unprotected	B	A	B	B	B	
Hardwood forests in Natura 2000 areas	B	B	B	B	B	
Hardwood forests in National Park	B	C	B	C	C	
Softwood forests unprotected	A	A	C	A	C	A to C
Softwood forests in Natura 2000 areas	A	B	C	B	C	B to C
Softwood forests in National Park	A	C	C	C	C	
Alien plantations unprotected	B	A	A	B	B	
Alien plantations in Natura 2000 areas	B	B	A	B	B	
Alien plantations in National Parks	B	C	A	C	C	
Grasslands unprotected	A	A	B	A	B	A to B
Grasslands in Natura 2000 areas	A	B	B	B	B	
Grasslands in National Parks	A	C	B	C	C	
Arable lands unprotected	C	A	A	C	C	
Arable lands in Natura 2000 areas	C	B	A	C	C	
Arable lands in National parks	C	C	A	C	C	

Tab. 5: Categorisation of habitat types according to different factors
Notes: PP = categories based on land price and legal protection status; PPV = categories based on land price, legal protection, and ecological vulnerability; Category codes: for land price: A: low land price; B: medium land price; C: high land price. Category codes for protection: A: not protected area; B: Natura 2000 area; C: National Park area. Category codes for vulnerability: A: not vulnerable; B: moderately vulnerable; C: highly vulnerable
Source: authors' elaboration

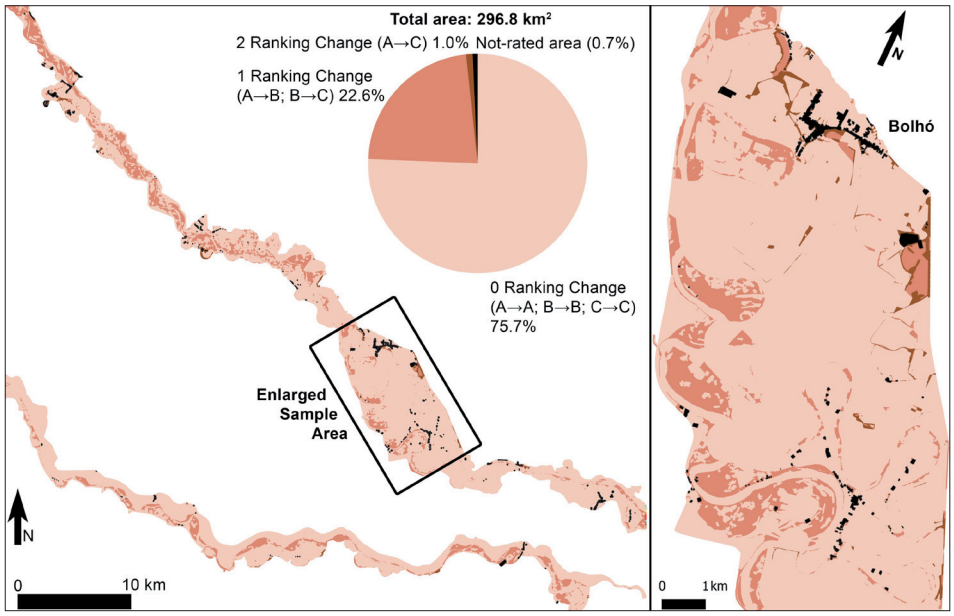

Fig. 6: Change of priority ranks
Source: authors' elaboration

Priority rankings, disregarding or regarding ecological vulnerability, significantly differed according to Spearman's (non-parametric) rank-order correlation coefficient. National Park areas are in the lowest priority category C, i.e. they are relatively well protected against the potential negative effects of FRM measures by conservational legislation, even if ecological vulnerability is disregarded. A National Park's conservation goals are declared in the legally binding management plans, which overwrites economic aspects in most of the cases. At the same time, habitats of high conservational value, such as softwood riparian forests, close-to-natural wetlands and wet or mesic grasslands are in the second, or even in the priority category (B, A) if they are lying outside of the National Park. As habitats in Natura 2000 areas are found in priority category B, it is questionable whether the Natura 2000 network provides adequate protection for these valuable habitat types (Wesolowski, 2005; Miklín and Čížek, 2014) especially in preventing the spread of IAS (Guerra et al., 2018). The situation is deteriorated by the fact that Natura sites are often fragmented and located in landscapes that are heavily invaded (Pyšek et al., 2013).

Regarding ecological vulnerability, four habitat types out of 21 (19%) with an area of 67 hectares (22.7 % of the total study area) have a lower priority for (i.e. less threatened by) FRM interventions: all Natura 2000 habitats, except hardwood riparian forests outside protected areas; and softwood riparian forests within Natura 2000 areas (those already in categories B and C, respectively).

The most important change is in the position of softwood forests. Floodplain softwood (*Salix-Populus*) forests represent the most widespread (36.3%) and most valuable habitat type, the only one of Natura 2000 priority. They belong to the most vulnerable habitat type in the study area and are among the most vulnerable ones at the European level (Chytrý et al., 2008; Janssen et al., 2016; Wagner et al., 2017). The observed intensive spread of woody IAS (their proportion in certain stands is as high as 25–30%) is a serious threat. Most widespread woody IAS are green maple (*Acer negundo*), American ash (*Fraxinus pennsylvanica*), to a lesser extent black locust (*Robinia pseudoacacia*), tree of heaven (*Ailanthus altissima*), furthermore Persian walnut (*Juglans regia*) and white mulberry (*Morus alba*), which are more and more common although not considered as an IAS in Hungary to date. Regarding only economic aspects, softwood stands in not protected areas are proposed as priority areas for FRMs, but regarding their vulnerability, they are relocated into priority category C. They indispensably need regular inundation of 2–8 weeks per year, so in their case conservational and certain FRM aspects are synergetic. Regular waterlogging, as a natural disturbance agent, is needed to maintain their continuously changing architectural structure with many deadwoods, rich tree regeneration and typical biota (Miklín and Čížek, 2014).

Flooding also prevents the spreading of many IAS, as e.g. *Robinia pseudacacia*, *Solidago gigantea*, *Aster* (*Symphiotrichum*) *spp*., but these species usually explode when the inundation fails. At the same time, inundation does not prevent the invasion of some other IAS, such as *Acer negundo*, *Amorpha fruticosa*, *Fraxinus pennsylvanica*, *Echinocystis lobata*. If softwood riparian forests are felled, e.g. for giving place to FRMs, natural regeneration may be made impossible by the invasion of IAS, e.g. a thick carpet of *Echinocystis lobata* or *Humulus scandens* (see photographs in Appendix).

Open waters and wetlands, such as oxbow lakes and their connected reed and sedge beds cover 15% in the study area (44 ha). Regarding only economic aspects, they belong to priority areas for construction works, as their market price is low. At the same time, they represent diverse relict habitats with exceptionally rich flora and fauna, and some of them include Natura 2000 habitats (Ortmann-Ajkai, 2018). Most wetland habitats (aquatic vegetation, reed and sedge beds) face the highest risk on the short term. Construction works may destroy them, but if the site receives proper water coverage after the works, in the longer run, within some decades they may regenerate reasonably well as landscape elements. Nevertheless, it is doubtful to what extent their ecological properties can be restored, even in the long term (Gulati et al., 2008; Bakker et al., 2013). Wetlands in not protected areas were categorised into Category B instead of Category A, which is favourable for their conservation.

Due to their ecological diversity (naturalness, size, species composition, habitat for protected species, pollution, etc.), there is a possibility for local negotiation, which may even help to reach win-win situations in cases of other trade-offs regarding more controversial issues.

There are inconsistencies and uncertainties in the case of grasslands. Similarly, to wetland habitats, grasslands in not protected areas were categorised into Category B instead of Category A. It is partly due to their diversity in ecological, economical and management aspects. This diversity is not represented in the average values used in our framework. As they cover only 22 hectares, 8% of the study area, there is a need and possibility for local negotiation. These negotiations may help to reach win-win situations.

Floodplain hardwood forests are less widespread in the study area, and even more disappeared from Europe, so their protection is of high importance for nature conservation. They need high groundwater levels, but intolerant to waterlogging for several weeks. Due to their more stable structure and slower natural dynamics, floodplain hardwood forests are more resilient to IAS than softwood ones (Chytrý et al., 2009). Older stands with deeply rooting trees survive, but changes in the herb layer indicate that these forests develop towards the mesic oak-hornbeam type (Kevey, 2018). After felling the stands, natural-based regeneration is problematic because of sinking groundwater level. Reforestation is implemented by planting native species. Young plantations need intensive care, which includes the eradication of woody IAS, but if management is improper, as in places which were expropriated from forestry use for FRMs, valuable native species, as pedunculate oak and Hungarian ash may be outcompeted by more generalist species, and aggressive IAS, such as *Robinia pseudacacia*, *Juglans nigra*, *Fraxinus pennsylvanica*, *Ailanthus altissim*a. FRMs, securing natural water retention for 1–2 weeks yearly is beneficial to the naturalness, and even productivity of hardwood forests, although forestry management operations may be hindered.

Invasive alien tree stands did not change category when ecological vulnerability is considered. Due to their economic value, they are not priority areas for FRMs according to our framework. Nevertheless, as they present an exceptional ecological threat to all natural (and sometimes also economic) values, converting them into stands of native species is a current challenge for conservation. FRM intervention may even be regarded as a conservational valuable measure for the eradication of IAS, which may compensate for economic costs.

The eradication of IAS is amongst the foremost serious current challenges to conservational management (Pyšek et al., 2013). There is a huge potential for synergies between water management and conservation, which can result in a more successful acquisition of funds (EC, 2011, Schindler et al., 2013) and attain better and prolonged practical results if the re-establishment of invasive species on the bare constructional grounds is prevented. The transformation of IAS stands to stands of native trees (which within some decades, and in case of availability of propagule sources for mixing tree species and native herbs, may develop into forests of medium naturalness) is one point of synergy between FRM and conservation interventions. Note that simply eradicating stands of IAS trees is not sufficient, since with lack of further management, they will quickly reappear because of their colonisation and competition potential is far higher compared to native species.

The above-mentioned priority rank changes inevitably mean restrictions and even extra costs for FRMs, but further considerations show that more synergies may help mitigate these negative effects. These synergies with the Habitat Directive and Water Framework Directive can and should be utilised in projects aiming at both FRM and conservation, rehabilitation, or even reconstruction of wetland habitats (EC, 2011; EEA, 2016). Vulnerable ecosystems need proper management to preserve their properties (Weisshuhn et al., 2018). In accordance, Pyšek et al. (2013) stress that legal protection needs to develop into the effective management of protected areas. Certain FRMs may act as a means of ecosystem conservation: see the case studies, for example in Gumiero et al. (2013).

4.2 Issues for future investigations

As our approach is quite novel, there remain several open issues which need special attention and may be improved through future applications.

If ecological values are also regarded during the planning process, FRM interventions may cause additional costs to landowners, but they also may have positive indirect economic advantages. They can equally mitigate the effects of floods and droughts. Softwood forests and grasslands may tolerate 1–3 weeks of waterlogging, so weak inundation (but not strong high floods) may even raise their naturalness and biomass production. Redirecting FRMs for present grasslands and arable fields instead of wetlands or softwood stands means higher costs in case of expropriation. But in certain locations, actual market prices of grasslands and arable lands in the National Park and Natura 2000 areas may be lower than average, because of management restrictions, higher flood risk in lower elevation (National Park areas are closer to the Drava river, so in a lower floodplain position), and often their more difficult approach by working machines. Inundation disturbs the work of land users, so raises their resistance, and motivates them to abandon these plots. The abandonment of meadows allows the spread of IAS, e.g. *Amorpha fruticosa*, *Solidago gigantea*, and *Robinia pseudoacacia*. On the other hand, temporal inundation of arable lands, as target areas of water retention, wet meadows can be created, facilitated by sowing the seeds of native grass species: these meadows can be utilised by hay-mowing or cattle grazing.

It must be underlined, that our study only concerns strategic FRM planning. The negative ecological effect of intervention works and destructive flooding, together with positive ecological effects, first of all, the improvement of the water supply of wetland habitats caused by natural water retention, is not possible to assess without exact spatial specifications of the planned FRM in question. When there are synergies between ecological and economic effects, in case of specific FRM interventions these should be utilised in cooperation between conservational and water management institutions during a comprehensive project-planning process involving all stakeholders. In these cases, the maximum precautionary principle should always be kept in mind.

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Appendices:

Appendix 1: Close-to-natural softwood riparian forest, a Natura 2000 priority habitat (91E0) in the study area, along a revitaliSed side arm which dries out at the end of the summer

Appendix 2: Huge Populus nigra in the study area. DBH>1 m

Appendix 3: Invasive species pose a serious threat to Natura 2000 habitats in the study area even in National Park areas, especially on the sites disturbed by construction works

Appendix 3a: On bare grounds left after construction works Symphyotrichium (Aster) species form a dense, thick carpet; Echinocystis lobata begins to creep over any other plants.

Appendix 3b: Softwood forests, are very sensitive to biological invasion, especially when disturbed: Impatiens glandulifera is a very competitive, large-sized nitrophilous species characteristic in these sites; huge curtains of Echinocystis lobata threatens even trees; in the herb layer masses of Solidago gigantea are also common.