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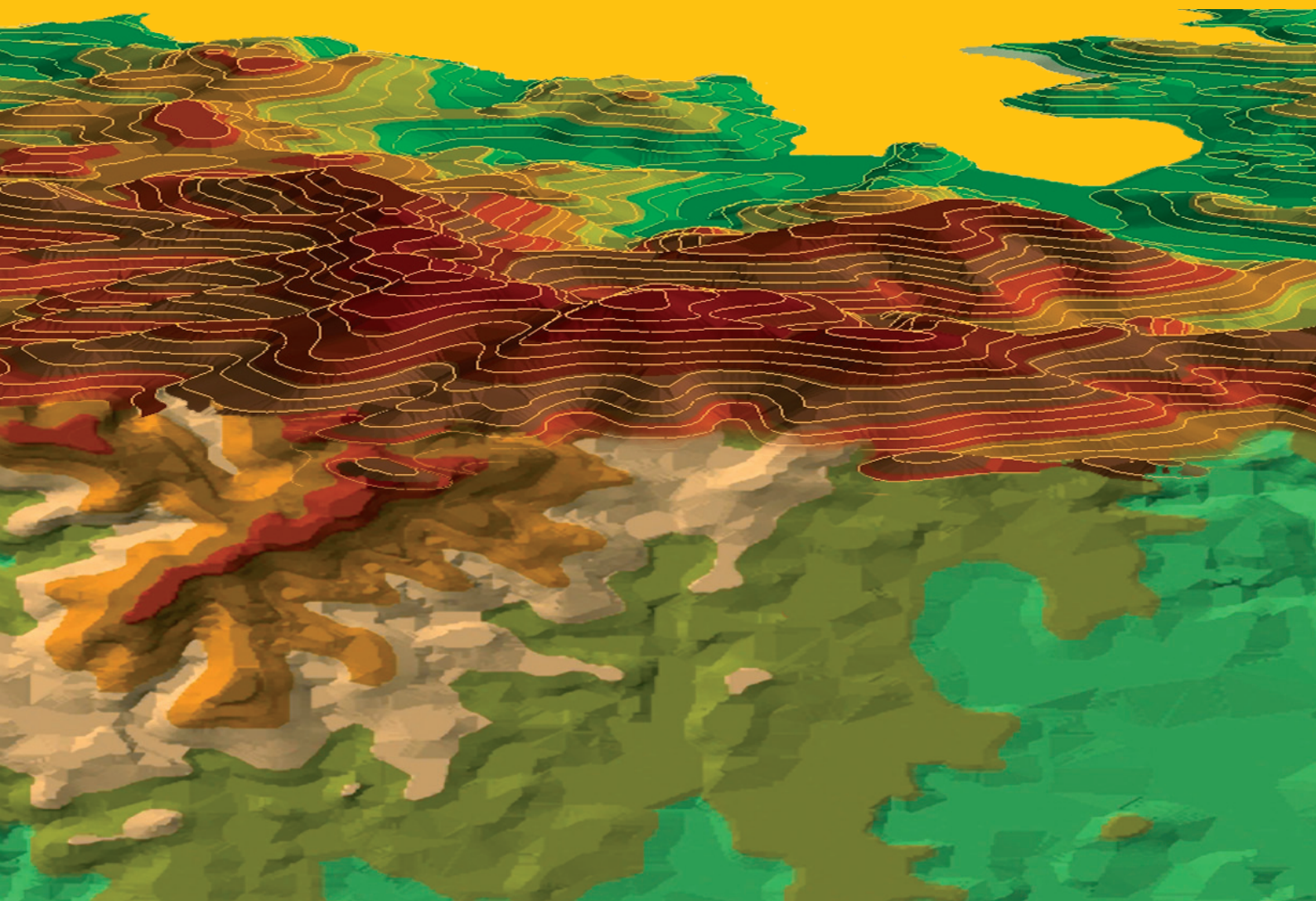

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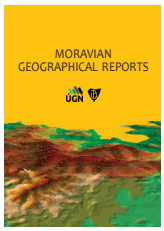

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Modelling the road network riskiness for motorcycle transport: The use of accident probability and accessibility to emergency medical service

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Abstract

Motorcycle users are generally perceived as one of the most vulnerable road user groups. It is therefore evident that, in addition to a range of prevention and awareness-raising activities, it is also necessary to identify specific locations where motorcycle users are at risk. We use a synthetic approach to identify the road network sections dangerous for motorcycle traffic. We perceive the risk level of individual sections as a complex combination of the causes (accident probability) and consequences (accessibility of medical services) of motorcycle accidents. The combination of both factors is then used to define the Road Network Hazard Index (RNHI) as a newly introduced indicator synthetically assessing the risk levels of individual road network sections for motorcycle traffic. The motorcycle accident probability on the Czech road network is extremely differentiated. The time accessibility of accident locations from EMS dispatch stations shows a clear correlation with the severity of motorcycle accidents. The model for the accident locations' accessibility indicates that the sparsely populated peripheral regions of the Czech Republic in particular show not only a higher motorcycle accident probability but also higher time accessibility values for emergency vehicles. The new RNHI provides a comprehensive view of the risk levels for motorcycle traffic in different Czech road network sections.

Keywords: *Motorcycle transport; road hazards; accessibility; traffic safety; Czech Republic*

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1. Introduction

Road safety has become an important transport priority worldwide. Many countries are therefore investing heavily in transport infrastructure and vehicles, as well as in transport education. The common goal of these efforts is to improve road safety for road users. The WHO estimates that transport accidents kill about 1.3 million people worldwide each year, and another 20–50 million people face the consequences of transport accidents www.who.int. There are also many other direct and indirect negative economic, social and psychological consequences (Bastida et al., 2004). The issue of transport accidents and their prevention has therefore long attracted the attention of researchers from various scientific disciplines. Recent academic debates, however have shifted from isolated accident research to looking at the more complex risks associated with road transport in general.

Today, a lot of attention is paid to the safety of motorcycle transport (Rodrigues et al., 2009; Jung et al., 2013 and Salum et al., 2019). Motorcyclist safety is also relevant due to the motorcycles' growing popularity worldwide. One of the reasons for the recent increase in its popularity is the global Covid-19 pandemic. Many people see motorcycle transport as a good way to eliminate interpersonal contact in public transport, while still meeting their mobility needs (see also Zhang et al., 2021). Although there is an overall downward trend in motorcycle accidents and their consequences, this decline is slower than in other means of transport. Motorcycle users are generally perceived as one of the most vulnerable road user groups and motorcycle accidents are often fatal (Di Stasi et al., 2011; Shinar, 2012; Rowden et al., 2016). The risks connected to motorcycle accidents are usually serious and the susceptibility to injury is high, especially in collisions with an obstacle or another road user. An important factor to ensure the fastest possible medical assistance in the event of a motorcycle accident is a reliable emergency medical service (EMS). EMS is a comprehensive system composed of personnel, facilities, and equipment to ensure efficient, coordinated, and timely delivery of health and safety services to victims of sudden illness or injury (Al-Shaqsi, 2010). Effective territorial coverage by the EMS system and their dispatch bases is thus a key factor for the entire healthcare system.

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Research on traffic accidents in connection with EMS and their medical response times is almost exclusively associated with car accidents, although motorcycle accidents account for roughly one-third of total traffic fatalities when compared to other transport modes (WHO, 2018) and time accessibility of EMS to a motorcycle accident is a key factor given the higher risk of severe consequences. Despite modern motorcycle safety features, such as ABS, and motorcycle equipment technologies including airbag vests (Serre et al., 2019; Thollon et al., 2010), riding a motorcycle is riskier than travelling by car due to the rider's vulnerability. Compared to car accidents, the risk of serious injury is higher due to the absence of a physical barrier or crumple zone.

The last decade has also marked the promotion of geographical approaches to the study of traffic accidents (see e.g. Kingham et al., 2011; Andersson & Chapman, 2011, or Bíl et al., 2013). This is because traffic accidents always have a spatial aspect. They always take place in specific temporal and spatial conditions. It was not until modern spatial analysis methods were developed, however, that spatial data was made more readily available, and geographic information systems (GIS) were introduced, that the importance of geographic approaches in traffic accident analysis grew. Thus, current geographic approaches often integrate spatial and traffic data. In addition, many countries now record accidents' precise locations as well as other characteristics, which allows for an adequate combination of spatial-statistical methods (Shafabakhsh et al., 2017; Shahzad, 2020). Although the factors influencing motorcycle accidents are relatively well researched (see e.g. a comprehensive study by Vlahogianni et al., 2012), a research gap still prevails. This is particularly evident considering the specific spatial patterns of motorcycle accidents and the associated coverage of the area by the health care system. A comprehensive approach to these risks is currently lacking. Therefore, spatial approaches are important to the study of motorcycle accidents and so is the related provision of post-accident health care (see also Sánchez-Mangas et al., 2010, or Bíl et al., 2019).

This paper aims to define complex road network hazards through spatial-statistical methods. The road network hazard index (RNHI) defined in this paper represents a new synthetic indicator to assess the risk levels of individual road network sections for motorcycle traffic. The RNHI design is based on a series of sub-steps specified below. In general, the RNHI uses the precise location of motorcycle accidents on the road network. This is then used to define the motorcycle accident probability in individual sections. It also utilises the time accessibility of accident locations from the nearest EMS dispatch station. The RNHI is then defined based on the interaction between accident probability and the EMS stations' time accessibility. This issue is of high social relevance as such approaches are currently lacking. The results of the study contribute to the current state of knowledge in the field of motorcycle accidents and their spatial aspects. They can also be applied when planning a territorial EMS coverage system or coordinating motorcycle traffic safety.

2. Theoretical background

Emergency response time (ERT) is a key factor in accident mortality and the chance of survival, and most deaths associated with traffic accidents occur before the subject reaches the hospital (Clark et al., 2012; Travis et al., 2012). The time elapsing between the accident and the emergency services arriving is therefore of the utmost value in terms of rescuing the persons involved in the accident (Clark et al., 2013). The available literature on accident rates and ERT mostly focuses on the relationship between the accident's consequences and the provision of health care. In general, improving medical care and technological developments contribute to reducing the health consequences of road accidents (Noland & Quddus, 2004). Developments in communication and GPS technologies also play a significant role in reducing EMS response time. Timely and accurate accident notification, including details such as type of accident, number of persons, severity, etc., are also among early rescue factors and contribute greatly to reducing post-accident mortality (Clark & Cushing, 2002; Lahausse et al., 2008; Wu et al., 2013; Plevin et al., 2017).

A key factor for the EMS' timely arrival to a traffic accident, however, is the distance between the accident scene and the medical centre. This depends on the different geographical conditions of accident blackspots and causes the difference in traffic mortality rates due to different ERTs (Li et al., 2008; Clark et al., 2013; Wilde, 2013; Byrne et al., 2019). Several studies (McCoy et al., 2013; Swaroop et al., 2013; Harmsen et al., 2015) have indicated a threshold interval of 15–20 minutes as the key EMS unit response time, after which a significant increase in patient deaths due to various types of trauma has been observed. In the Czech Republic, the EMS deployment system is regulated by legislation. According to the Emergency Medical Services Act (374/2011 Coll.):

> "the plan for the coverage of the territory with EMS stations determines the number and location of EMS stations depending on the demographic, topographic and risk parameters of the territory of individual municipalities so that the location of an incident in the territory of individual municipalities can be reached from the nearest EMS station within a response time of up to 20 minutes" (§5).

Thus, the time elapsed between the incident notification and the arrival of EMS units at the accident scene has a significant impact on increasing the survival rate. This factor has subsequently become an international standard for EMS station localisation, especially in urban environments. The situation is different in rural areas, however, which are often less accessible. There are usually issues with lower quality road infrastructure and longer commuting distances. Consequently, "blind spots" in the territory arise, most often in rural and sparsely populated regions with lower EMS density (He et al., 2018; He et al., 2019; Xiong et al., 2022).

Accident localisation is a key factor related to the quick EMS arrival. Research in how accident location is related to EMS response time has shown a significant difference between accidents in rural and urban areas (Kmet & Macarthur, 2006; Alanazy et al., 2019). The difference between urban and rural EMS performance in achieving better patient rescue outcomes has been demonstrated by several studies conducted exclusively in developed countries. American research on EMS arrivals to accident scenes revealed a significant difference in medical response time; the model for urban environments showed significantly shorter arrival times to accidents than the model for rural areas (Gonzalez et al., 2009; Newgard et al., 2017). Similar findings were reported by the Polish researchers (Aftyka et al., 2014), who found that EMS in a rural area has a significantly longer response time than in an urban location. The increased accessibility and performance of EMS in an urban environment is in turn related to road infrastructure density and its quality relative to the location of EMS stations. On a trans-regional scale (e.g. the Czech Republic), however, EMS travel times are determined by spatial complexity and geographical characteristics such as the terrain or road network sinuosity. Studies such as Liu et al. (2014) and Amorim et al. (2017) explain the higher accident rate as a result of densely populated urban environments with developed infrastructure.

Detailed accident information from Automatic Crash Notification systems (ACN), which currently offer the possibility to locate the accident immediately and determine its crash characteristics by analysing the data transmitted from the vehicle, can also influence medical response time. This data is evaluated in real-time by EMS units. The emergency service must identify accidents with serious injuries and deploy appropriate rescue and treatment capacities

according to the type and severity of the accident. These systems' contribution to reducing the mortality rate in traffic accidents has been demonstrated by studies such as Clark and Cushing (2002) and Bahouth et al. (2014).

3. Data and methods

We use the traffic accident database in the Czech Republic provided by the Police of the Czech Republic. The database contains all transport accidents reported to the Police from January 1, 2016 to December 31, 2020. All accidents involving motorcycle drivers have been selected from this database. The database contains 10,460 motorcycle accidents happening during the entire period. Each accident recorded in the database contains its detailed characteristics, i.e. time, date, exact coordinates of the accident (latitude, longitude), and a lot of other information.

Our methodological approach is based on an attempt to synthesise the risk levels of individual road network sections for motorcyclists. The risk levels of individual road network sections are defined as a combination of the probability of a motorcycle accident occurring on a given section and the nearest EMS station's time accessibility, which plays a key role in saving human health and life in the event of an accident (see Azimian et al., 2021). This process consists of the following steps.

In the first phase, we study the motorcycle accident probability in all sections of the Czech road network in detail. To determine the probability, we first observe the spatial concentration of motorcycle accidents in each section of the road network. The road network sections were taken from the road network database managed by the Road and Motorway Directorate of the Czech Republic and the Technical Road Administration of Prague. Sections are generally defined as parts of the road network between two junctions. The advantage of choosing sections using this method is that each section contains information about the average daily motorcycle traffic intensity. A total of 9,334 sections covering almost 33,800 km (more than 61% of the Czech road network) are recorded in this database. It therefore contains a substantial part of the busiest roads in the Czech Republic.

The concentration of traffic accidents is expressed as the number of motorcycle accidents in individual sections in the given period divided by the length of the relevant road network section. This process identifies specific concentrations of motorcycle accidents in individual road sections. We then divide the specific concentrations of the road network's risk sections by the motorcycle traffic volume in the section. The data on motorcycle traffic volume in each section are taken from the national traffic census results from 2020. Thus, we know the average daily motorcycle traffic volume (number of motorcycles passing in 24 hours) for each section. This figure is then multiplied by the number of days in the whole reference period using the formula

$$P(x) = \frac{N(s)/l}{T(x) \times (5 \times 365)}$$

where $P(x)$ is the accident probability in x coordinates per 1 km of road length, N is the number of accidents in the segment, s is the segment containing x, l is the length of the segment, and T is the average motorcycle traffic volume in 24 hours according to the results of the national traffic census.

Based on the proportion of the values in the spatial concentration of motorcycle accidents and the total intensity of motorcycle traffic, each section of the Czech road network is defined in terms of the motorcycle accident probability.

Based on previous findings (see e.g. Kraft et al., 2022), it has been confirmed that motorcycle accident blackspots exhibit specific spatial patterns. It is generally true that motorcycle accidents occur away from major thoroughfares, on lower road classes, and further from population centres. This harms the time accessibility of accident locations from EMS stations, which are usually located in urbanised areas (see Xia et al., 2019). Therefore, in the second phase, we monitored the time accessibility of each road section from the nearest EMS station. We measure it as the amount of time needed to reach a particular road network section from the nearest EMS dispatch base. The exact EMS station locations were taken from the individual regions of the Czech Republic's coverage plan. In total, we work with 327 EMS dispatch stations. We determine the time accessibility through the Network Analyst extension in ArcGIS Pro. The individual sections connecting the starting point (the EMS dispatch base) and the destination (the centre of the surveyed road section) are assigned average speeds (according to ČSN 73 6100-2). The time required to reach the destination is then calculated for each section. Based on this sub-procedure, we define the accessibility of individual accident locations, which significantly influences the chances of rescuing injured persons.

We calculated the dependence of traffic accident severity on EMS time accessibility using the local contingency table introduced in Dvořák and Mrkvička (2021). We divided the accessibility into 4 categories: up to 10, 20 and 30 minutes and longer. Each accident's severity was rated according to the average insurance company's claim for injuries to reach the overall RNHI. Thus, we created a model of the injury severity from the insurance company's perspective. A subjective model from the injured person's perspective could also be made, but for the sake of objectivity, we chose to create the model from the insurance company's perspective. The average insurance claim values were obtained from Česká pojišťovna, a.s. data (Tab. 1).

	Severity = Average claims in CZK
Death	420,000
Serious injury	34,521
Minor injury	13,741
No injury	0

Tab. 1: Average claim values based on the accident's severity
Source: authors' calculations based on discussion with expert (see above)

The resulting road network hazard index (RNHI) is a combination of the above sub-processes. The RNHI is calculated for each section of the road network. Its value is determined as the product of the accident probability in a given section and the mean accident severity value identified by the frequency of individual accident categories occurring (death, serious injury, minor injury, no injury). Thus, the overall formula for calculating the RNHI value is:

$$\text{RNHI (of segment s)} = \text{P(x)} * \text{E(accident severity} \mid \text{accessibility = D)}$$

$$\text{E(accident severity|accessibility D)} = \\ = \sum_{i \in \{Death, serious\ injury, minor\ injury,\ no\ injury\}} severity * P(i|D),$$

where $P(i|D)$ is the probability of phenomenon i, subject to the availability of D, which is determined by the contingency table (see Section 4.2)

4. Results

4.1 Motorcycle accident probability

In the first phase, we assess motorcycle accident probability in individual sections of the Czech road network. This characteristic is based on the number of accidents, the length of individual sections and the intensity of motorcycle traffic. This indicator has a significant predictive value in terms of motorcycle safety.

It defines the relative risk sections of the road network for motorcycle traffic. The motorcycle accident probability is shown in Figure 1.

The probability of a motorcycle accident is spatially differentiated in individual sections. An increased motorcycle accident probability can be observed, especially on sections of lower-class roads (2nd and 3rd class roads). At the same time, there is an increased concentration of such sections in less urbanised parts of the Czech Republic (e.g. Nunn & Newby, 2015). This makes some sense as population centres become important sources and destinations for individual motorcycle rides (see e.g. Iamtrakul et al., 2003). Nevertheless, the accident rate is particularly high in their surroundings, where the likelihood of motorcycle accidents increases due to the popularity of more remote roads with less traffic among motorcycle riders (Cater, 2017). This confirms previous findings that specific concentrations of motorcycle accidents occur on less busy roads further away from population centres (e.g. Kraft et al., 2022).

Most motorcycle accidents occur on sections of 2nd class roads with generally low traffic volumes. The section between Chudenice and Švihov in the south-western part of the Czech Republic has been identified as the riskiest in terms of motorcycle accident probability. The sections in rural regions located further away from urban areas predominate among the twenty sections with the highest motorcycle accident probability. Another key observation is that these are, with few exceptions, long sections (the average length of the section is 6.8 km) with no junctions. The road sections where a greater number of risk factors intersect (unclear horizon, multiple sharp curves, poor visibility conditions, etc.) have been identified as sections with a high motorcycle accident probability. These sections in particular should draw more attention from the authorities responsible for road safety (see also Bíl et al., 2019). Identifying sections with high motorcycle accident probability is undoubtedly the key to further improving motorcycle traffic safety and implementing effective measures to eliminate them (Kashani et al., 2014). The accumulation of risk sections on lower-class roads can also be illustrated by data on the road network structure showing the probability of motorcycle accidents (Tab. 2).

4.2 Time accessibility of accident localities from the nearest EMS

As discussed above, the time accessibility of health services is one of the key post-accident aspects in saving human life and health. Given the specific motorcycle accident concentration spatial patterns noted above, this availability is often hampered by the fact that motorcycle accidents tend to occur in remote locations with lower traffic volumes, higher elevation, more curves, etc. (Jiang et al., 2020). Accidents involving quad bikes and enduro motorcycles in very inaccessible forest or mountain locations are no exception, however, which makes transporting injured people to medical facilities much more difficult. This is evidenced, among other things, by Figure 2 showing the locations of motorcycle accidents

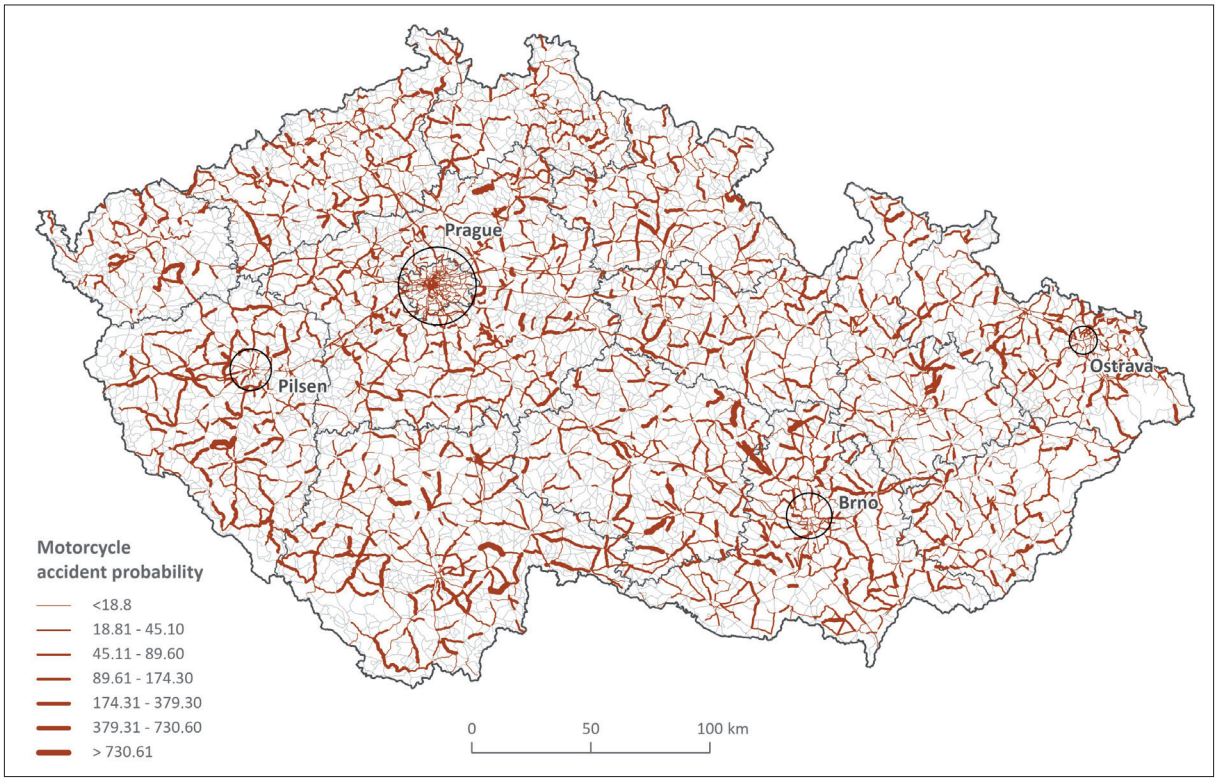

Fig. 1: Motorcycle accident probability on road segments in the Czech Republic
Source: authors' elaboration based on data from www.policie.cz and www.rsd.cz

Road class	Number of motorcycle accidents	Average daily motorcycle traffic volume	Average accident probability
Freeways	314	105	23.26
1st class roads	3,034	75	23.49
2nd class roads	4,535	39	53.99
3rd class roads	1,277	30	70.88
Urban roads	2,432	161	19.87
Local and other roads	800	80	25.30

Tab. 2: Road network structure according to number of accidents, average daily motorcycle traffic volume and motorcycle accident probability
Source: authors' calculations based on data from www.policie.cz and www.rsd.cz

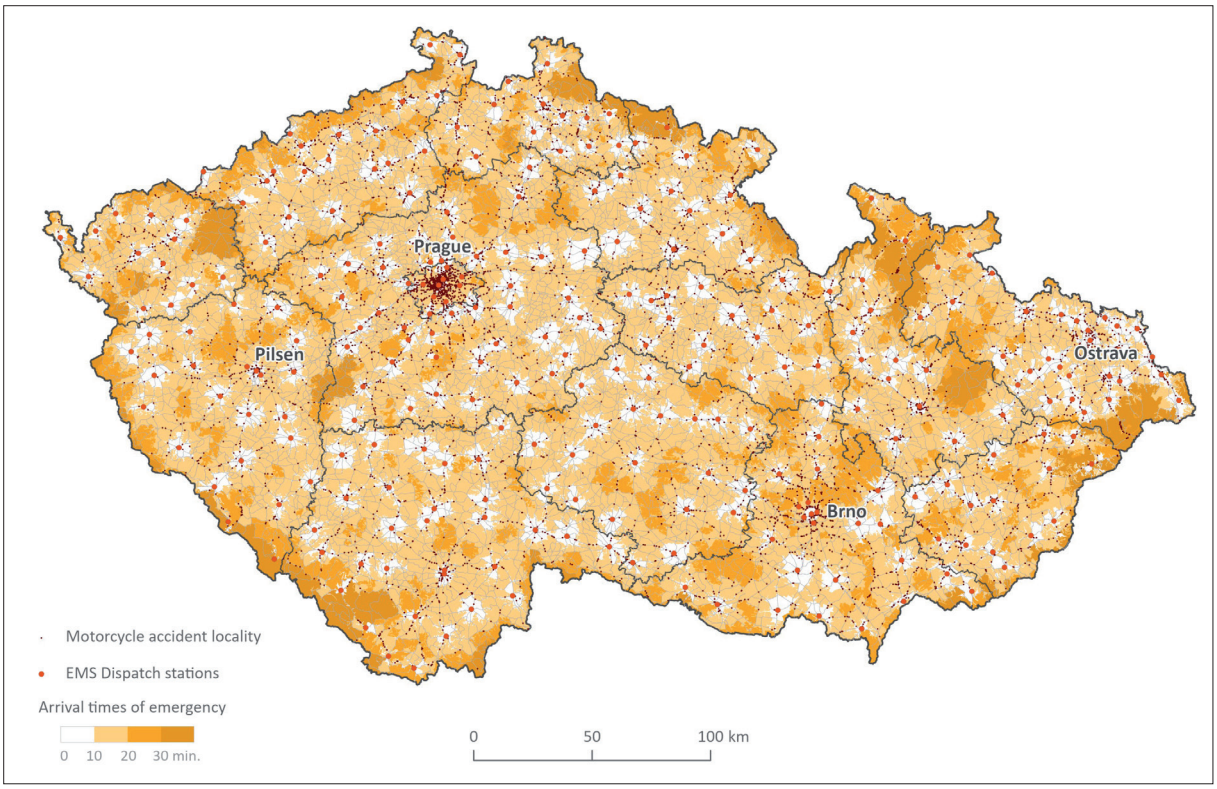

Fig. 2: Time accessibility zones from the nearest EMS to accident locations
Source: authors' elaboration based on data from www.policie.cz and Emergency Medical Services Act (374/2011 Coll.)

in relation to the nearest EMS station's temporal availability. Although the Czech Republic's EMS system coverage is relatively good (see e.g. Dolejš et al., 2020), one can also find locations where the nearest EMS station is very inaccessible.

It is evident that the statutory 20-minute accessibility (see above) cannot be adhered to in some accident locations. However, the overall coverage of the EMS dispatch stations according to motorcycle accident locations is relatively good. Nearly half of the accidents happened in locations accessible within 10 minutes from the nearest EMS (see Fig. 3). The lowest time accessibility values are usually found in urbanised regions where the population is more concentrated, the road network is denser and therefore there are more EMS dispatch stations. Especially considering the specifics of the motorcycle accidents' spatial distribution, however, the accidents often occur in very remote locations, i.e. with worse accessibility values. Such locations can be found especially in less accessible areas further away from cities, in rural regions and mountainous areas. Such sections are concentrated especially in the mountainous border regions of the Czech Republic. Although the road network is much thinner here, motorcycle accidents occur quite often (see e.g. Rezapour et al., 2020). In addition, intervention by air ambulance is more complicated in these regions.

We calculated the traffic accident severity as dependence on EMS availability using a local contingency table. The reported local results are bound by the global p-value of the test = 0.001 based on 1,000 permutations. The local results are presented in Table 3.

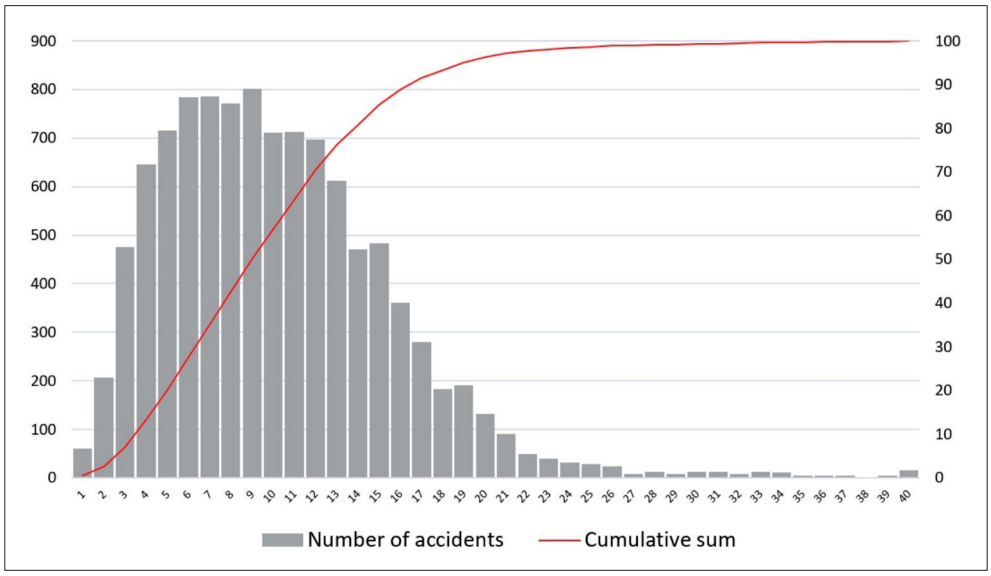

Fig. 3: Number of accidents according to the accessibility from nearest EMS
Source: authors' calculations based on data from www.policie.cz and Emergency Medical Services Act (374/2011 Coll.)

Severity/Minutes	0–10 minutes	11–20 minutes	21–30 minutes	More than 30 minutes
Death	119	102	10	4
Serious injury	579	518	48	12
Minor injury	4,054	2,759	216	53
No injury	1,205	742	31	8

Tab. 3: Statistical dependence of motorcycle accident severity on EMS accessibility
Note: The combinations marked in green show that there are fewer cases than there should be under independence. On the other hand, combinations marked in red show that there are more cases than there should be under independence.
Source: authors' calculations based on data from www.policie.cz and www.rsd.cz

This test shows that more serious injuries occur in cases with EMS availability of 11–20 minutes, while more cases with no injuries occur in cases when EMS availability is under 10 minutes. Furthermore, there are fewer cases of serious injuries with availability under 10 minutes and fewer cases of no injuries for 21–30 minutes. The mosaic exploratory plot further suggests that this trend already appears in the case of 10-minute availability but is more apparent for the 20-minute availability. Since the data for 20 and 30-minute availability are sparse, the difference is not proven, even though it is larger.

4.3 Road network hazard index

The synthetic Road network hazard index (RNHI) is a combination of these two approaches. Thus, on the one hand, it uses the identified probability of a motorcycle accident occurring in specific sections of the monitored network, but on the other hand, it operates with information on the time accessibility of the nearest EMS dispatch station for individual sections. This approach can therefore be seen as a synthetic approach to motorcycle accident risks and their spatial aspects. Based on the methodological approach described above, each road network section is assigned an RNHI value as a product of the motorcycle accident probability and the nearest EMS station's time accessibility expressed in terms of the financial insurance claim's mean value by accident type. The combination of both factors shows the actual risk for motorcycle users (see also Gutierrez-Osorio & Pedraza, 2020).

The results indicate that individual road network sections in the Czech Republic show significantly differentiated RNHI values. The sections with the highest RNHI values are those with a high motorcycle accident probability, which are also relatively far from EMS dispatch stations. This is further confirmed in Figure 4. The combination of the two chosen factors (accident rate and remoteness) is evident in the sections with the highest RNHI values. Again, these are generally road sections on lower-class roads (2nd and 3rd class roads) in rural areas, where the risk of an accident with a high temporal availability value from the nearest EMS station is evident.

The sections defined in this way reflect the risks of individual road sections for motorcycle traffic comprehensively. In general, the lowest RNHI values tend to be in urban areas, which are relatively safe in terms of possible motorcycle accidents. EMS vehicles' accessibility also tends to be very good there, which significantly increases the chance of patient survival in post-accident care (Hashtarkhani et al., 2020; Xiong et al., 2022).

Moreover, these characteristics are relatively evenly distributed across urban areas, as there are no significant differences between urban regions. The situation is very different in rural and remote areas of the Czech Republic (see Travis et al., 2012). Here, the RNHI values differ significantly. Especially in the eastern part of the Czech Republic, the RNHI values are relatively low. The rural areas in this region tend to be characterised by larger

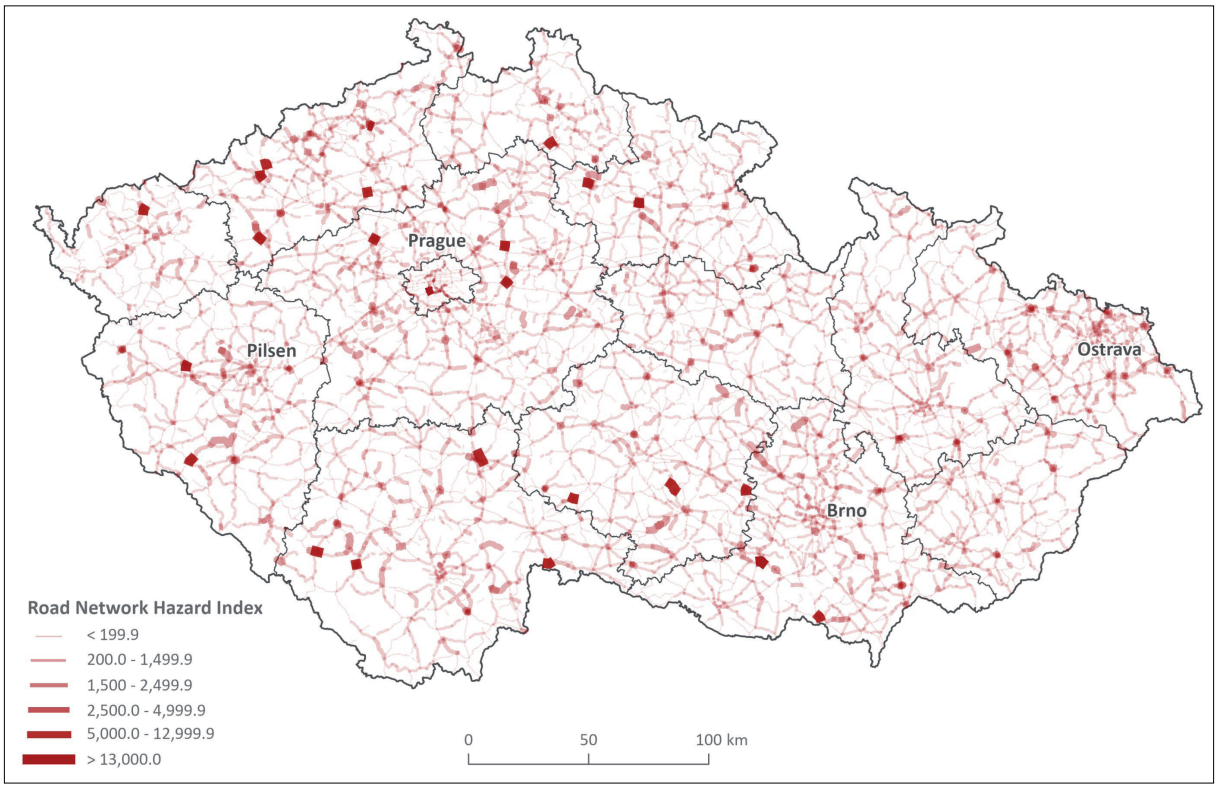

Fig. 4: Road network hazard index (RNHI) for individual road sections in the Czech Republic
Source: authors' elaboration based on data from www.policie.cz, www.rsd.cz and Emergency Medical Services Act (374/2011 Coll.)

rural settlements with very good service provision (including health services). On the other hand, the highest RNHI values are found in rural areas in the central and western half of the Czech Republic. These regions are characterised by lower population density, lower road density and dispersed settlements. The higher RNHI values is typical for so-called "inner peripheral areas" of the Czech Republic. These areas are located on the borders of autonomous administrative units (regions of the Czech Republic) with many negative socio-economic phenomena (see also Pileček et al., 2013 and Klapka et al., 2020). These negative socio-economic characteristics (low population density, low service provision, lower road network density, etc.) further negatively affect the risk level of road sections for motorcycle traffic.

5. Discussion and conclusions

Motorcycle safety is among the main priorities and challenges of many countries' transport policies. It is therefore evident that, in addition to a range of prevention and awareness-raising activities, it is also necessary to identify specific locations where motorcycle users are at risk. In this paper, we have used a synthetic approach to identify the road network sections dangerous for motorcycle traffic. We see the risk level of individual sections as a complex combination of the causes and consequences of motorcycle accidents (see also Xie et al., 2019). We have described the causes of accidents as an accumulation of various risk factors directly affecting motorcycle accident rates. Thus, we define the probability of a motorcycle accident based on accident accumulation in each section of the road network. The consequences of motorcycle accidents are monitored through accident severity and the accident locality accessibility for health service vehicles. The combination of both factors is then used to define the RNHI as a newly introduced indicator synthetically assessing the risk levels of individual road network sections for motorcycle traffic.

The results of our study have shown that the risk levels of individual road network sections for motorcycle traffic vary considerably. The most important results can therefore be summarised as follows:

- The motorcycle accident probability on the Czech road network is extremely differentiated. Its levels are influenced mainly by the road class along with other factors (unclear horizon, multiple sharp curves, poor visibility conditions, etc.). These sections are concentrated in less urbanised regions, especially in the south-western part of the Czech Republic;
- The time accessibility of accident locations from EMS dispatch stations shows a clear correlation with the severity of motorcycle crashes. An interval under 20 minutes shows significantly more favourable values for less severe injuries than intervals above 20 minutes, where the categories of severe injuries and fatalities caused by the accident are significantly more pronounced. Moreover, the model for the accident locations' accessibility indicates that the sparsely populated peripheral regions of the Czech Republic in particular show not only a higher motorcycle accident probability but also higher time accessibility values for emergency vehicles; and
- The newly introduced RNHI provides a comprehensive view of the risk levels for motorcycle traffic in different Czech road network sections. It confirms, among other things, that the highest risk level is characteristic for lower-class roads in areas further away from large population centres. In these regions, the negative factors caused by higher motorcycle accident probability and higher time accessibility values for emergency service vehicles from EMS dispatch stations, accumulate. Thus, in the case of sections with the highest RNHI values, there are multiple risks caused by the combination of both factors which influence motorcycle traffic safety negatively.

The results of the study are partly influenced by the fact that a model condition is used to determine the accessibility of the EMS dispatch stations. This condition occurs when there are no other incidents reported in the vicinity of the EMS station and the emergency vehicle crew is ready to depart immediately. It is often the case, however, that the crew is not at the station, for example, due to responding to another reported incident (see Enayati et al., 2018). In such a case, the second closest crew is called (often from another dispatch station), which increases the time required for transport to the accident locality and back. This information could become more accurate by gathering actual data on the medical service vehicles' movement (GPS records), but these are currently unavailable for the Czech Republic in general.

The main results of this study could become a useful resource to implement effective measures within the Czech Republic's transport policy. In this context, we would like to point out that motorcycle transport is, with few exceptions, not included in transport policies and does not receive as much attention as other transport modes (Pinch & Reimer, 2012). The results of this study could therefore have obvious practical applications, such as introducing specialised navigation applications designed for motorcyclists or installing traffic signs notifying motorcyclists of the risk levels on certain road network sections.

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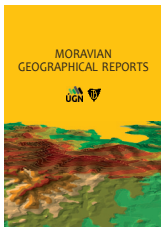

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Spatial patterns of EU funds absorption in Romanian rural municipalities

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Abstract

This study analyses the spatial differences in EU funds absorption among Romanian rural municipalities through the 2014–2020 programming period. The absorption capacity for EU funds is measured by the volume of spent EU funds by inhabitant, for each Romanian rural municipality. The results of the analysis highlight the importance of the territorial dimension when studying the distribution of EU funds among the rural municipalities of Romania. Affiliation with a specific development region (NUTS 2), county (NUTS 3) or a functional urban area (FUA) is used to differentiate the volume of absorbed EU funds. In Romania, rural municipalities with higher levels of absorbed EU funding are, to a statistically higher extent, located in development regions in the Centre, North-West, South-West and West of the country; in communes with no change, or even an increase, in population between 2014 and 2021; in the highest quartile of fiscal capacity and in communes with experience with EU funding from the preceding programming period. This article adds to the growing body of territorial evidence and can be used as a policy instrument to more closely examine the intervention tools embedded in EU funding policy.

Keywords: *structural funds; rural municipalities; funds absorption, Romania*

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1. Introduction

Romania became a member of the European Union in 2007. Since that time, a substantial volume of EU funds has been available for a diverse set of potential beneficiaries, including rural municipalities. Although territory represents an important characteristic in EU funding policy design, highly disaggregated analyses of the results of all sources of EU funding are scarce. This article addresses this gap by providing research results from an extensive dataset on EU funding for all rural municipalities in Romania.

The aim of this study is to identify and analyse the spatial differences in EU funds absorption for Romanian rural municipalities in relation to the 2014–2020 programming period. The absorption capacity of EU funds is measured by the volume of spent EU funds by inhabitant for each Romanian rural municipality. The research area is Romania, and the research period is 2016–2021, which corresponds to registered payments of EU funds to local budgets during the programming period of 2014–2020.

Data have been processed in such a way (see section 4.2) as to allow comparisons between municipalities from Romania as well as, if the case occurs, municipalities from other EU countries. The absorption capacity is expressed in euro at constant 2010 prices per inhabitant and reflects the sum for the entire period of 2016 to 2021. The process of data management can be replicated within different spatial contexts in other EU member states at the local administrative unit (LAU) level. Moreover, the publicly available database on which the current study is based can provide grounds for further analyses and comparative approaches, as subject to data availability.

The study's novelty rests on an analysis of spatial differentiation at the lowest disaggregated level throughout the entire rural space in Romania. Whereas the national and regional (NUTS 2) levels are more addressed, less is known about the counties (NUTS 3) and even much less about the LAU level. Since EU funding policy at least partially aims at reducing disparities, a spatial analysis of EU fund absorption by municipalities is an essential tool for evidence-based policy making. Unlike some of the preceding examples, we explore this topic by analysing actual payments made rather than allocations, and in addition, we add the annual absorbed funds into a global sum that best reflects the multiannual absorption capacity for the entire programming period.

The paper is structured as follows. Section 2 outlines some of the approaches to EU fund absorption from a territorial perspective. Section 3 presents the general characteristics of rural municipalities in Romania to better contextualise the paper's results within the national frame of reference. Data sources and analysis methods are presented in Section 4, while the results and discussion are presented in Section 5 and Section 6, respectively.

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The final section, Section 7, provides conclusive remarks and suggestions for next steps and the further use of results analysis at the EU, national and local levels.

2. EU funds absorption: Various approaches from a territorial perspective

The absorption capacity for EU funds has been studied at multiple levels, including the national (EU Member State) level, the operational program (across the EU and/or member states) level, the NUTS 2 level, the NUTS 3 levels and, in the same vein as that in the current study, the LAU level. EU funds absorption has been analysed also in relation to the timeframes prior to the implementation of the EU funded projects/programs (as a type of ex-ante assessment), as well as during the implementation and upon its completion.

At the member state level, applying a systemic view of absorption capacity groups the macroeconomic conditions, co-financing capacity and administrative capacity on the supply side, whereas the capacity of beneficiaries to prepare projects rests on the demand side (Šumpíková et al., 2006). Good governance and financial capacity have been identified as belonging among the factors that differentiate levels of EU fund absorption among EU member states (Achim & Borlea, 2015), alongside administrative capacity (Marinas & Prioteasa, 2016; Ţigănaşu et al., 2018), government effectiveness and fighting corruption (Incaltarau et al., 2020) and high income levels (Tosun, 2014)[1]. Under the same level, ex ante assessments of the absorption capacity of Romania indicated a rather preliminary stage of preparations at the onset of the first programming period (Oprescu et al., 2006) and the need to integrate perspectives between the European and national levels of operation (Cace et al., 2009).

At the regional level, several regional characteristics highlight the presence of 'pro-cohesion' policies in disadvantaged areas (Collins et al., 2017), together with the role of administrative capacity, which in turn is influenced by political interference, government stability and political accountability (Milio, 2007); the importance of studying regional absorption capacities within the context of multilevel governance (Cunico et al., 2022); the high relevance of the means by which regional absorption capacity is actually computed, alongside the means by which political accountability is shared between regions and the EU (Aivazidou et al., 2020); the significance of an integrated approach, including the motivations of public servants and the political salience of policies (Domorenok et al., 2021); and the context in which 'artificially created' NUTS 2 regions can absorb EU funds (Maier et al., 2021). The term 'artificial' refers here to the process of constructing NUTS 2 regions in Romania, in the sense that it mirrors only statistical associations of counties. They have been developed in 1998, in response to the need to allocate and coordinate EU pre-accession funds like Phare programs. Correspondingly, the National Institute of Statistics has eight regional directorates and, computes, similar to other EU countries, statistics at regional level (in addition to the county and LAU levels). Nonetheless, in the next programming period Romania has distinct regional operational programs for each region, which makes a more decentralised management level of the EU funds in respect to this funding line.

A previous analysis performed at the NUTS 2 level differentiates the type of regions in the analysis of factors used to determine EU funds absorption (Kersan-Škabić & Tijanić, 2017). The study differentiates between convergence regions (GDP per capita of less than 75% of the EU average) and development regions (GDP per capita of more than 75% of the EU average). Labour force characteristics, decentralisation, investments, the institutional framework, and infrastructure development all count in this respect. Labour force characteristics are measured in reference to the educational level, and the unemployment rate is a variable with a significant influence on the successful absorption of EU funds in all NUTS 2 regions, while the institutional framework, as measured in relation to good governance and control of corruption, is an important indicator, especially in convergence regions (Kersan-Škabić & Tijanić, 2017). The same factor, quality of governance, has been studied in relation to EU fund absorption as measured at the regional level and used as a standard deviation (reflecting the differences between the national average and the disbursed amounts) in the Bulgarian context, in which the regions are similar to those in Romania, as "there is no equivalent administrative territorial unit but only statistical regions" (Kalfova, 2019, 6). Further on analyses conducted at NUTS 2 level, a complex analysis highlights that the quality of regional government stands out as a significant predictor for Cohesion Policy performance – measured under three key dimensions – compliance, absorption and achievements (Mendez & Bachtler, 2022).

At the NUTS 3 level, the importance of both contagion and diffusion territorial processes and the significance of financing needs are highlighted in previous analyses (Maier et al., 2022). The cited analysis considers only those EU funds absorbed from the Common Agricultural Policy and managed through the AFIR (Agency for Financing Rural Investments). It emphasises the importance of spatial analyses that have been assimilated to contagion and diffusion, or a "longitudinal clusterisation," from East to West. The paper concludes as favouring factors being located in the Western part of Romania and making use of more performant local institutions (Maier et al., 2022).

At the municipality level, the beneficiary's capacity to initiate, conduct and successfully implement EU-funded projects can also be regarded as an input variable that influences the overall absorption capacity at the member state or operational program level (Boeckhout, 2002). Furthermore, regarding the municipalities, earlier research identified a typology of successful and passive municipalities (Cyburt, 2014), the role played by administrative capacity (Marin, 2015), the spatial position of municipalities in relation to the main urban centre of the subregion, the level of municipal socioeconomic development, local leadership (Cyburt, 2014), the absorption and development levels of the rural community, availability and the characteristics of state budget funding (Marin, 2021), residence areas (Hochhholdinger et al., 2021) or institutional arrangements (Maier et al., 2021), the financial situation of local communities (Mirska, 2021), and the importance allotted in EU policy to specific needs, such as demographic decline, which affect rural areas (Weber et al., 2020).

A complex analysis of the development indicators of rural territorial units from Poland shows the importance of spatial attributes and the necessity of refining the allocation logic of the cohesion policy to develop the conditions necessary for the improved use of local resources (Gospodarowicz, 2022). Size and proximity to the central area are particularly emphasised as important factors in the delineation of different lines of development within rural areas, especially in the case of those which remain decoupled from the polycentric nature of the spatial structure (Gospodarowicz, 2022). Within the same country context, the importance of the local budget, the level of development and the "degree of deagrarianisation" of local economies is emphasised for the spatial distribution of the EU's Cohesion Policy (CP) at the rural level (gmina/commune) (Komorowski, 2021).

[1] In reference to a specific fund, namely, the European Regional Development Fund's (ERDF) for the programming period of 2000–2006

A prior analysis of the determinants of EU funds absorption by communes in a Polish region highlights the importance of previous experience using EU funds, as the employees of mayoralties have the opportunity "of learning incomprehensible language of programmatic documentation and complicated system of estimating the eligible costs" (Standar, 2010, 104). The same article stresses the importance of establishing a comprehensible prefunding system or ensuring access to credits, which, in their case, refers to preferential credits from the fund managed by the Bank of National Economy (BGK) (*ibid.*).

At the theoretical level, however, the discussion would benefit by enhancing the perspective with the following concepts and relationships relating to the characteristics of the funding environment:

i. Complexity, or the complex knowledge required by the environment;
ii. A lack of stability or dynamism, as measured by the rate of change in the environment; and
iii. Resource availability, or the level of available resources in the environment (Sharfman & Dean, 1991, 683).

This theoretical lens views municipalities as open public organisations that influence and are influenced by their environment. From this perspective, the absorption capacity of municipalities can be influenced by many factors at the macro and meso levels, among which the programming phase of EU funds for each implementation period plays a key role. A good match between explicit or implicit local priorities and eligible funding lines at the national level is not always met. In addition, even when this match is achieved, the co-funding rates cannot be supported for all needed and eligible funding objectives. Hence, one of the key questions regards the application process itself, which is not captured by the analysed data. For instance, it is difficult to say whether all the areas examined in this article have actually tried to submit EU funded projects and whether they were eligible for specific EU funding lines. Moreover, some of the funding lines even offer 'predetermined' projects, thus the idea of 'open competition' becomes no longer valid.

One approach that can capture a systemic view of external fund absorption and its relationship to its environment comes from the field of organisational sociology, which views organisational effectiveness as "the ability of the organisation, in either absolute or relative terms, to exploit its environment in the acquisition of scarce and valued resources" (Yuchtman & Seashore, 1967, 898). This capacity is assimilated as a "bargaining position" for the organisation, or "a more general capability of the organisation as a resource-getting system" (*ibid.*). Although this definition seems to be appropriate in the case of EU funding, it is still difficult to operationalise in an integrated model that encompasses all types of environmental influences that impact an organisation. It can be the case that some of these influences, such as resource availability, can significantly influence both annual absorption capacity (such as the delayed opening of certain Operational Programs) and overall absorption capacity.

Earlier research has analysed the importance of EU funds compared to funds from the largest of the state budget-funded programs (PNDL II) (Marin, 2021), especially at the county level. The current study considers absorption capacity to be a process variable, in which prior experience from the first programming period (2007–2013) is considered. Hence, as a process variable, it is difficult to establish the causality of absorption capacity, as in some instances, a good absorption capacity in the preceding programming period can attract highly qualified human personnel, which acts as a positive influence in the studied timeframe. It is still possible that some LAUs attracted a high volume of funds during the 2007–2015 timeframe that required a high co-funding rate, which would have left little room for co-funding projects in the programming period of 2014 to 2020. A multiannual plan of public investments, which has already been initiated in the national fiscal budgetary strategy for 2020–2022 (Ministry of Public Finance, 2019), can contribute to solving this issue.

The same problem is anticipated regarding a World Bank project on the coordination of investment priorities that uses an estimate on prudent capital expenditure margins for county councils (World Bank, 2016, 759). Another problem, also related to fiscal capacity, is that of the sustainability of the implemented investment. In this sense, previous studies computed a specific index for the financial sustainability of investments conducted in rural areas, particularly for road and social infrastructure (World Bank, 2016).

Absorption capacity can be viewed as a particular type of organisational capacity. In its turn, organisational capacity can be defined according to i) analysis layer, ii) stage of the project cycle, iii) dimensions; or iv) function. Depending on these elements, the definitions of organisational capacity have many similarities with those of absorption capacity. If one considers it as a stage of the project cycle, the definitions of organisational capacity as a result or impact focus on the issue of organisational effectiveness (Bryan, 2011). In terms of dimensions and/or function, capacity as a resource is a perspective that emphasises the function of attracting resources, similar to the absorption capacity (*ibid.*). In this paper, absorption capacity is used in the sense of organisational effectiveness, related to allocating financial resources.

One of the first systematic studies (as considered by Wostner, 2008) conducted on absorption capacity in relation to the topic of structural funds has been conducted at state level by Boot et al. (2001). Similar definitions and analysis patterns are used in the report for DG Regio/DG Enlargement (Boeckhout et al., 2002). A systemic vision, delimiting the demand (beneficiaries) from the supply (managing authorities) of structural funds is introduced at the state level (the absorption capacity was considered equivalent to the macroeconomic capacity in the first phases of studies on this topic).

Within the field of organisational sociology, the theory of open systems (Katz & Kahn, 1966) encompasses a systemic view on the organisations and acknowledges the two-sided facet of influences from the organisations into the environment, as well as from the environment on the organisations. This view is aligned with the perspective on absorption capacity as a specific type of organisational effectiveness, placing the emphasis on the organisation's relationship with the environment, in the sense of the organisation's attempt to attract resources from the environment.

As a summary of the variables listed above, explanatory factors for organisational effectiveness tend to make a distinction between organisational and environmental factors (Moynihan & Pandey, 2005, 423). Both categories of factors are essential, and there is also a certain overlap between them. The product of interaction with the environment – autonomy and resources can be used by managers to use organisational variables (Moynihan & Pandey, 2005, 424). If we focus the analysis at the level of individual public organisations such as municipalities or territorial administrative units, explanatory variables can be grouped under the following categories: organisational factors related to (i) administrative capacity (including specialised personnel, systems and procedures), financial capacity, size of the organisation, partnerships with other organisation, previous experience with EU funding, whereas environmental factors pertain to: (ii) spatial attributes of the locality (including affiliation to a particular regional development level); (iii) demographic/social structure of the administrative unit and/ or locality's general development level; (iv) structure of local economies, or (v) macroeconomic variables (related to the Member State's overall absorption capacity, logic of allocating resources from EU funds and State Budget, etc.).

Correspondingly, this paper explicitly analyses, based on the availability of data, the following types of factors:

- Organisational factors, such as (a) financial autonomy (fiscal capacity), (b) previous experience with EU funding, (c) availability of State Budget funding for the organisation, and
- Environmental factors related to (d) spatial attributes – (d1) affiliation to a specific development region, (d2) being part of a functional urban area, (e) community level variables – demographic and social structure of the locality – (e1) population dynamics and (e2) presence of a marginalised community within the locality and (f) overall level of development of the locality (composite index, summing up several social and economic indicators).

Nonetheless, the most important questions regard the impact of EU funds on local development and on improving citizens' quality of life. This is in fact the key aspect of the relevance of this topic. Prior analyses conducted at the municipality level for countries in Central and Eastern Europe have shown that there is a positive impact on local socioeconomic development; however, it is difficult to state the scale of this impact, especially given the long-term impacts of some EU-funded programs (Spychała, 2020). Additionally, as with the EU funds absorption capacity, several factors have been identified relating to the differentiated impact of EU funds, including the level of territorial capital (Fratesi & Peruca, 2014). A recent study on Romania highlights the growing regional disparities regarding the high absorption capacity of EU funds that is mostly attributed to capital cities (county seat municipalities) (Sandu, 2022).

The current study centres around characteristics at the locality level and analyses the characteristics of EU funds absorption as related to locality factors. The locality's absorption capacity, however, also relates to that at the national-, regional- and county--levels to varying degrees. We do not account for this in our analysis, so it should be subject to further analyses in the future.

3. Geographical context: The general characteristics of rural municipalities in Romania

This section briefly introduces the key characteristics of local public administration in Romania to ground the results reported in the next part of the paper in a more contextualised understanding.

The Romanian system of public administration is represented by a two-tier local government structure including 3,181 municipalities (3,180 municipalities plus the municipality of Bucharest, the capital city) and 41 county councils. The open database used for analyses includes 3,187 cases of local public administration organisations, as it also covers the six districts of Bucharest, which are organised as separate municipalities of Bucharest. In fact, the six municipalities of Bucharest are given a different set of responsibilities than the rest of the municipalities in Romania. This is why they generally require a distinct analysis path to achieve meaningful results, especially when compared to the rest of the urban municipalities in Romania.

The set of 3,181 municipalities includes 2,862 rural municipalities[2], 217 towns and 102 cities[3]. Local and county council representatives are elected. The members of the local councils (municipalities) are elected both by secret ballot and by direct suffrage. The legal framework does not include a statement on subordination relationships between the two levels of public administration – the county and the local councils. County represents the second tier of local public administration and there are 41 counties in Romania. In each county, there are several urban and rural localities, but there are no formal subordination relationships between the counties and territorial administrative units (for more information on NUTS 3 codes in Romania, see Eurostat (2023)). The Administrative Code states that the relationships between local and county public authorities are based on the principles of local autonomy, legality, cooperation, solidarity, equal treatment and responsibility (art. 85, para 1). The same legal document affirms that there are no subordination relationships between these two structures, but rather that they have a collaborative relationship (art. 85, para 2). The fundamental law of Romania, however, which is the text of the Romanian Constitution, mentions that the county council represents the public authority for coordinating the activity of rural and urban local councils to supply county-level public services (Article 122 of the Romanian Constitution). The mayors are the executive bodies of the local councils/municipalities. The president of the county serves as its leader.

The territorial structure of Romania's rural area is fragmented, and it includes a substantial number of municipalities that have 5,000 or fewer inhabitants. These municipalities represent more than one-third of the population of the total number of municipalities (excluding the municipality of Bucharest). Moreover, data from the latest available Population Census (2011) show that approximately one-quarter of the rural municipalities in Romania contain under 2,000 inhabitants. It would be very useful to compare these population data with the updated census data from 2022 to identify the differences. A small population of less than 2,000 inhabitants can be a significant challenge for a municipality applying for EU funding, especially in the case of public physical investments, such as water, sewerage or sanitation.

The level of fiscal autonomy among Romanian rural municipalities significantly varies by development region (Tab. 1). The municipalities from the lower quartile of fiscal capacity (as measured by revenues per inhabitant) are more likely to come from the Northeast and Southwest development regions. In contrast, the rural municipalities from the upper quartile of fiscal autonomy, to a much higher extent, come from the development regions of West, North West, Centre and Bucharest-Ilfov. These four development regions are precisely those regions of Romania with the highest GDP per capita. In fact, measured against the EU-27 average, the development region of Bucharest-Ilfov comes in above the EU-27 value. It is the only development region in Romania with a higher value than the EU-27 average (purchasing power standard (PPS, EU27 from 2020), per inhabitant in percentage of the EU27 (from 2020) average, Gross domestic product (GDP) at current market prices by NUTS 2 regions [NAMA_10R_2GDP], Eurostat database.

The size of the local budget and level of fiscal autonomy are important not only in the provisioning of general public services but also specifically for the topic of this study, for ensuring the co-financing aspect of EU-funded projects. Communes that place in the upper quartile of fiscal capacity are more likely to cover the co-funding requirement of a large-scale project and therefore can attract a higher volume of EU funding. As shown in Table 1, all communes from the highest development region, Bucharest-Ilfov, place in the upper quartile of fiscal capacity. Notably, Table 1 presents the pre-pandemic levels of fiscal capacity as a three-year average. It is possible that the level of rural fiscal capacity might be significantly different when computing the average values of 2020, 2021 and 2022 separately.

Development regions in Romania are not part of the local public administration structure. Although we present results as

[2] The Baneasa municipality from Constanta County was considered a city until 2019, when it was reclassified as a commune. In the current analysis, we consider it to be a rural locality.

[3] Annex to Law No. 290/2018, Statistical situation documentary on administrative organisation of Romania's territory.

		Fiscal capacity				
		Lower Q	Medium – low Q	Medium – upper Q	Upper Q	Total
Development Region	North East	71.1	20.0	5.3	3.6	100
	South East	23.9	28.4	26.1	21.6	100
	South	28.9	25.2	33.3	12.5	100
	South West	35.0	45.1	13.7	6.1	100
	West	5.0	13.9	28.5	52.7	100
	North West	7.4	32.8	31.8	28.0	100
	Centre	*	19.3	40.1	38.9	100
	Bucharest-Ilfov	0.0	0.0	0.0	100.0	100
	Total (N)	788	757	700	617	2,862
	Total (%)	27.5	26.5	24.5	21.6	100

*Tab. 1: Fiscal capacity by development region: Rural localities in Romania (%) (Notes: Q = quartile. Gray cells indicate significantly higher values (adjusted residuals), * indicates a value of lower than 10 cases. Fiscal capacity is measured as municipal own revenues by inhabitant (in constant euro at 2010 prices, per inhabitant), with values averaged for the years of 2016, 2017 and 2018)*
Source: authors' calculations, based on public data regarding local budget execution for all communes in Romania

disaggregated by this territorial dimension, development regions in Romania are statistically constructed. They have been set up in relation to EU programming fund absorption, but it is important to note that unlike other EU countries, Romania does not match them with corresponding structures of local public administration. The landscape of fragmented local administrative units, coordination issues between a significant number of local and central public authorities, as well as poor financial autonomy in the case of rural administrative units have been put forward as some of the key needs for which a territorial reorganisation would be needed. For particular funding lines, especially for the Common Agricultural Policy, local action groups (GAL) have been used as a case to increase administrative capacity and, potentially, effectiveness of EU funds. Local action groups represent partnerships between public institutions and private or civil stakeholders. Latest available data (November 2022) indicates a list of 237 local action groups which cover a large part of the rural territory (Ministry of Agriculture and Rural Development, 2022). In addition, intercommunity development associations also represent an example of further integration of territorial administrative units, with the county as being one of the possible partners of this type of association.

Given the characteristics of the local public administration in Romania, several attempts to introduce territorial administrative reorganisation have been submitted in the past, yet, without success. The objectives of decreasing regional inequalities, coupled with increased regional financial autonomy (Dragoman, 2011) have also been advocated in favour of a meaningful territorial administrative reform. Potential explanations for these unsuccessful attempts are also attributed to "the weak effect of the European acquis regarding regional policy" that resulted in setting up statistical regions without accompanying decision-making responsibilities (Salageanu, 2012).

4. Data and methods

4.1 Data sources

The cumulative EU funds for the period of 2014–2020 are based on financial data from local budget execution, as published by the Ministry of Development, Public Works and Administration, Directorate for Local Fiscal and Budgetary Policies (2021).

4.2 Data aggregation

The data management process involved merging all the information for all the localities in Romania by assigning correct unique identification codes (SIRSUP, LAU 2 codes) for all municipalities for each the analysed years. The entire process of data aggregation is presented in the technical description of the EU FAR open database (Marin et al., 2022a). The category of EU funds from the programming period of 2014–2020 is registered as a distinct category in the local budgets' execution beginning in 2016 (nonetheless, this also delays approval of the corresponding operational programs and certification of management authorities). Notably, the information in the database refers to payments (executed budget) rather than allocations and includes all sources of EU funding, irrespective of the funding line (European Regional Development Fund, European Social Fund, or Norwegian cooperation programs).

The key variable of the study represents the total sum of EU funds, expressed in euro at constant prices per inhabitant.[4] The data management process involved converting the sums reported by municipalities in Romanian lei (the national currency) at the end of each year into Euro at constant 2010 prices per inhabitant: Eurostat indicator [NAMA_10_GDP], 2010 = 100. GDP and main components (output, expenditure and income), Price index (implicit deflator), 2010 = 100, euro, National accounts indicator (ESA 2010), Gross domestic product at market prices. The population information comes from the National Institute of Statistics – Tempo online database – Pop107D, Population by home (as of January 1), by age group, gender, counties and localities. The detailed explanation on the process of data transformation and aggregation is described in Marin et al. (2022a). The exact steps and indicators for this process are described in the technical description of the EU FAR database. In earlier research, the absorbed funds at the national and NUTS 2 level were aggregated by standard deviation, rather than by sums, as a measure of regional policy efficiency (Kalfova, 2019) that was based on a localisation of the project at the NUTS 3 level. The current paper, however, uses funds already localised at the LAU level from all EU funding lines. It uses the summative approach of expenditures, which is also used in the spatialisation and harmonisation of a large dataset regarding payments from the Common Agricultural Policy (Nicholas et al., 2021).

4.3 Data analysis

In this article, we use the term 'rural' to refer to the territorial organisation of the country. The detailed classification is openly available from the National Institute of Statistics (see Tempo online database, 2022). On the basis of this classification, there are currently 2,862 municipalities (communes) in the rural area of Romania. Therefore, we do not consider the classification of LAUs or communes into three types of area on the basis of density that is used by Eurostat, according to which rural areas correspond to thinly populated areas and more than 50% of the population lives in rural grid cells (Eurostat, 2020).

[4] Variable name in the database: [SUM_EU_2016_2021_inhab]. For values per year, the following variables are available: [SUM_inhab_2016], [SUM_inhab_2017], [SUM_inhab_2018], [SUM_inhab_2019], [SUM_inhab_2020] and [SUM_inhab_2021]

Several predictors have been systematically tested in reference to the volume of absorbed EU funds, including the level of fiscal capacity (the average value of a municipality's revenues in euro at constant 2010 prices per inhabitant), affiliation with a development region, county and functional urban area (FUA), population dynamics in 2021 compared to those in 2014, EU funding in the previous programming period of 2007–2013 (as registered in the local budgets execution reports for 2016 through 2021), the presence of a marginalised community, funding from state-budget programs, and level of development. A complete list of variables used in the analysis is available in the Appendix of this article.

4.4 Limitations

It would be useful to further disaggregate the data by type of accessed operational program, as budgetary coding allows for this refinement of data. The format for budgetary reporting includes separate codes for funds originating from the European Regional Development Fund, European Social Fund, Cohesion Fund, European Agricultural Fund for Rural Development, European Fund for Fisheries and those funds corresponding to the European and Economic Space, as well as to other programs. Nevertheless, in the current format of budget execution, this information is not recorded by the operational program.

Another limitation of the analysis is that it implicitly assumes a high degree of homogeneity among eligible conditions for accessing EU funds for rural municipalities, which is in fact not always the rule. For instance, the volume of EU funds differs according to the regional degree of development (GDP per capita less than or greater than 75% of the EU average). Moreover, municipalities from counties in border regions can also benefit from an increased volume of funds through territorial cooperation operational programs.

Another limitation of the database relates to missing information about the leaders of the municipalities throughout the analysed period. The analysed data are for the period of 2016 to 2021, yet Romania underwent general local elections in September–October of 2020. It would be useful to know whether there has been continuity in the mayor's position and whether the mayor's political affiliation changed as a result of those elections. However, the current format for publicly displaying data on local elections does not allow for this type of analysis.

5. Results

5.1 General results

The peak of EU funds absorption by Romanian rural municipalities occurred in 2020. Table 2 shows that both the highest average value for 2020 and the greatest amount of absorbed EU funds are the highest values for the maximum level for the same year. Consequently, the largest standard deviation again occurs in 2020. In contrast, the low volumes that were absorbed in 2016 indicate an early stage of preparations for contracting and implementing projects in the 2014–2020 programming period. Additionally, the commune with the highest level absorbed almost double the funds of the commune with the next highest level. In total, over the whole period, in reference to the last variable used in Table 2, fewer than 50 communes achieved an absorption volume of more than 1,000 Euros in constant 2010 prices per inhabitant.

5.2 Characteristics of categories of EU funding in rural areas

This section presents the results of the analysis, making a distinction between municipalities with zero funding from the programming period of 2014–2020 and those that succeeded in securing various levels of funding from the entire volume of EU funds available for Romania. In total, there are 462 municipalities that are considered 'white spots' on EU funding during this timeframe, out of which 25 municipalities are from urban areas and 437 municipalities are from rural areas. This analysis shows the importance of spatial location (NUTS 2 and NUTS 3 levels) to the identification of white spots for EU funding. As EU funding policy mainly rests on development indicators such as GDP per capita at the NUTS 2 level, the study can provide a comprehensive lens for identifying regional differences in the white spots of EU funding in Romania. Additional lines of statistically significant differences have been identified regarding fiscal capacity, population dynamics, EU funding in the previous programming period, state budget funding, level of development and inclusion in a FUA.

Rural municipalities with the lowest levels of EU fund absorption (including cases of localities with zero funds) from Romania tend to occur at a significantly higher extent in the South development region of Romania.

In contrast, the rural municipalities with the highest levels of EU fund absorption are more likely to be located in the Centre, North West, South West and Western development regions. Compared to the EU-27 average, only the development region of Bucharest-Ilfov is above the EU-27 average (purchasing power standard (PPS, EU27 from 2020) per inhabitant in percentage of the EU-27 average and the GDP at current market prices by NUTS 2 regions [NAMA_10R_2GDP]). In this respect, the development region of the North East has the lowest value, followed by that of the South, South West and South East (data for 2019). Consequently, the regions with the highest values (with the exception of Bucharest-Ilfov region) of GDP per capita are the Western, Northwestern and Central regions. Therefore, the highest levels of EU funds absorption are associated with some of the highest levels of GDP per capita, with the exception of the Southwestern region (see Tab. 3).

Nevertheless, the development region of Bucharest-Ilfov, which registers the highest GDP per capita, presents contrasting characteristics and tends to also be associated with the cases of white spots of EU funding. Cases of communes that did not absorb any EU funding occur to a statistically higher extent in the development region of Bucharest-Ilfov. For a nuanced interpretation, it is important to mention that we examine only the role of rural municipalities in this paper and, nonetheless, the development level of the entire region is associated with that of the capital city, which is a dynamic not covered in this analysis.

	EU funds per inhabitant in						
	2016	2017	2018	2019	2020	2021	Sum of 2016–2021
Mean	1.8	14.1	24.1	36.1	43.8	35.4	155.3
Median	0.0	0.0	0.3	7.1	7.5	3.2	45.9
Std. Deviation	17.8	55.9	62.1	70.2	93.6	82.3	242.8
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	353.3	1264.7	850.0	777.1	1,862.2	1,585.8	2,517.8
Sum	5,147.8	40,252.3	68,948.3	103,460.8	125,459.9	101,338.4	444,607.6
Number of cases	*2,862*	*2,862*	*2,862*	*2,862*	*2,862*	*2,862*	*2,862*

Tab. 2: Descriptive statistics for EU funds absorbed by rural municipalities
Source: authors' calculations based on the EU FAR database. The values are expressed in euro at constant 2010 prices per inhabitant

		Volume of EU funds from the 2014–2020 programming period					
		Zero funding	Lower Q	Medium – low Q	Medium – upper Q	Upper Q	Total
Fiscal capacity	Lower quartile	14.2	14.5	29.7	22.0	19.7	100
	Medium-low quartile	12.7	8.5	27.5	25.0	26.4	100
	Medium-upper quartile	14.4	8.7	25.1	23.9	27.9	100
	Upper quartile	20.7	8.9	17.7	22.5	30.1	100
Development Region	Bucharest -Ilfov	78.1	*	*	*	*	100
	Centre	6.2	8.1	22.1	28.3	35.3	100
	North East	14.8	12.6	23.1	27.9	21.5	100
	North West	8.2	9.4	22.6	23.8	36.0	100
	South	26.0	13.5	30.6	17.7	12.1	100
	South East	16.6	10.7	28.2	22.0	22.5	100
	South West	11.0	7.6	29.2	22.1	30.1	100
	West	15.3	7.5	21.0	24.6	31.7	100
EU funding in the programming period of 2007–2013 (in 2016–2021)	No	16.9	11.3	27.9	22.7	21.2	100
	Yes	10.7	7.5	18.5	25.1	38.2	100
Population dynamics in 2021 compared to 2014	Decrease of more than 10%	21.5	7.7	30.6	19.3	20.9	100
	Decrease of less than 10%	14.3	10.6	26.6	23.4	25.0	100
	No change or increase	14.5	10.7	18.8	25.4	30.5	100
Presence of a marginalised community	No	15.7	9.9	25.4	23.6	25.4	100
	Yes	14.4	11.1	25.4	22.9	26.2	100
Part of Functional Urban Area (FUA)	No	15.0	10.4	26.0	22.8	25.8	100
	Yes	20.3	8.3	12.8	33.8	24.8	100
State budget funding	No	21.6	10.6	26.5	19.7	21.6	100
	Yes	14.6	10.2	25.3	23.7	26.1	100
Level of development	Developed	14.9	11.1	20.0	27.7	26.3	100
	Getting out of poverty	19.8	7.4	26.8	20.8	25.2	100
	In stagnating poverty	13.0	11.7	30.0	20.5	24.9	100
	Dynamic average developed	15.9	8.5	27.6	23.1	24.9	100
	Stagnating average development	11.3	10.5	22.6	26.6	29.0	100
	Higher average dynamic development	18.3	10.3	22.1	20.6	28.6	100
	Missing information	20.7	10.3	15.2	31.7	22.1	100
Total (%)		15.3	10.3	25.4	23.3	25.7	100
Total (N)		437	294	727	668	736	2,862

*Tab. 3: Characteristics of the volume of EU funds absorption for the rural municipalities of Romania (%) (Notes: Q = quartile; * represents less than 5 cases; grey cells indicate significantly higher values [adjusted residuals])*
Source: authors' calculations

Additionally, cases of white spots in rural areas tend to occur in the development region of the South, as already mentioned.

At a more disaggregated level, namely the county level (NUTS 3 level), the communes that place in the upper quartile of EU funds absorption are more likely to be from the counties of Bistriţa-Năsăud, Cluj, Harghita, Hunedoara, Mureş and Tulcea. Within this set of counties, Cluj has the highest GDP per capita (after Bucharest) in Romania. Cluj county has a value of 29,800 purchasing power standard (PPS, EU27 from 2020) per inhabitant (Eurostat database, GDP at current market prices by NUTS 3 regions [NAMA_10R_3GDP]). This indicator for the rest of these counties, Bistriţa-Năsăud, Harghita, Hunedoara, Mureş and Tulcea, range from 15,500 (Bistriţa-Năsăud) to 17,400 (Hunedoara) (Fig. 1).

At the county level, the communes that place in the lowest quartile of EU funds absorption (as distinct from the ones lacking EU funding) tend to be from the counties of Bacău, Dâmboviţa, Galaţi, Neamţ, Satu Mare, and Sibiu. In the case of Brasov county, there are less than 10 cases. Regarding the case of white spots from rural areas, a previous analysis shows that they tend to occur in the counties of Argeş, Brăila, Constanţa, Giurgiu, Ialomiţa, Ilfov and Vaslui to a greater extent (Marin et al., 2022c). Additionally, if we complete the picture at the NUTS 3 level by using a composite territorial quality of life index, we see that, in contrast to the GDP/capita measure, Hunedoara and Bistriţa-Năsăud counties have higher values than, for instance, Cluj county. Nevertheless, when reading these results, it is important to consider that at the NUTS 0 level in the European context, Romania places in a low position as a whole (ESPON, 2016).

Contrary to the expected relationship, there is no statistically significant correlation between the categories that measure EU funds level absorption and the typology of rural marginalised communities. Several possible explanations can be proposed here. On the one hand, the presence of a marginalised community has been taken into consideration in several EU funding lines. Furthermore, these marginalised communities partially overlap with disadvantaged communities, as in the case of disadvantaged schools in the Operational Program for Human Capital (POCU 2014–2020). This does not mean however that it is certain that the funds absorbed by municipalities, including by this type of community, have actually been spent on disadvantaged communities. This question can only be assessed when information at a more disaggregated level is available, namely, information at the village level (SIRUTA inferior). An example of this type of analysis conducted for projects funded by Romania's largest State Budget Program (National Program for Local Development (PNDL 2)) is available in Marin (2021). Communes that place in the upper average quartile of EU funds absorption (but not the highest quartile) tend to be developed communes, where development is measured on the basis of the index compiled by Professor Dumitru Sandu. In addition, communes in the lower average quartile belong to the category of 'stagnating poverty'.

Levels of EU funds absorption by rural areas tend to have an ambivalent relationship with the degree of financial autonomy of the municipality. We have computed indicators on financial capacity as a mean average for the first three years of available data (2016, 2017 and 2018) in constant 2010 Euro per inhabitant as well as in shares of own revenues to total revenue. In this case, communes in the highest quartile of EU funds absorption also tend to be in the highest quartile of fiscal capacity. Communes without EU funds in this programming period, however, tend to be in the highest quartile of fiscal capacity too. To provide a better analytic lens to this subject, it might be useful to examine fiscal capacity considering the years of 2014 and 2015 as starting points for the examined programming period, yet this has not been the case in our study.

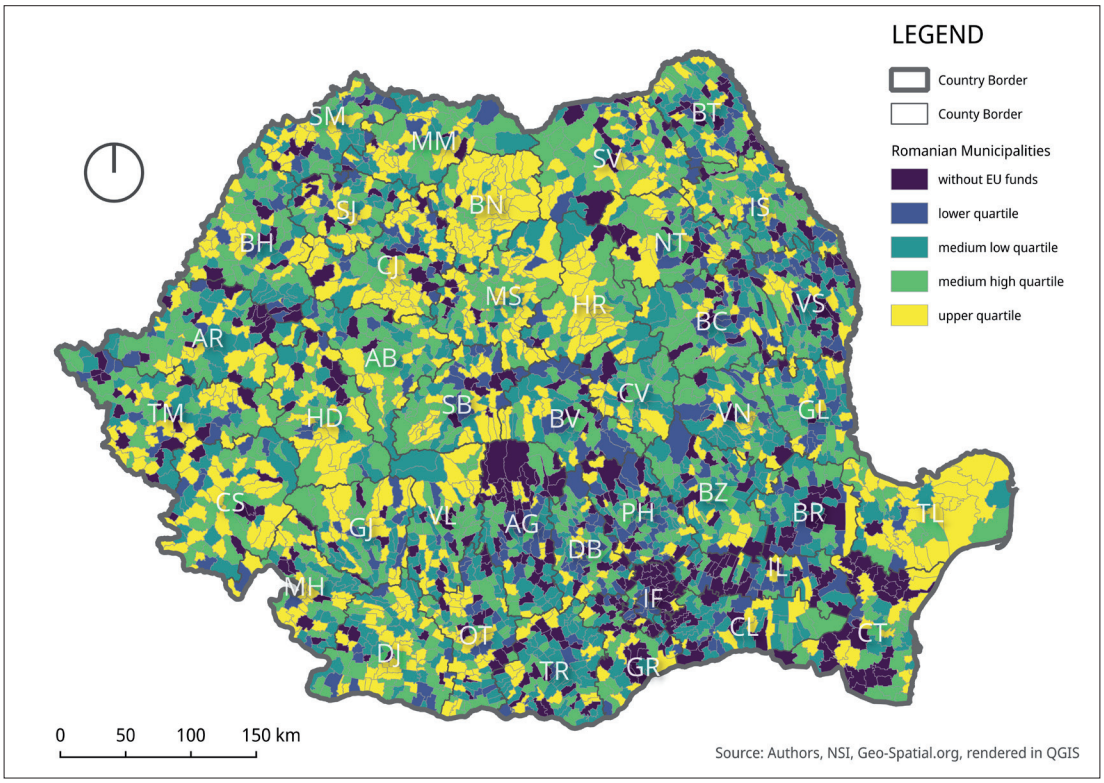

Fig. 1: Distribution of volume of EU funds among Romanian municipalities (Note: The above map presents results for all Romanian municipalities, including the cases of 2,862 rural municipalities)
Source: authors' elaboration based on EU FAR Database

EU funds absorption in the prior programming period (2007–2013) is relevant to the level of absorption in the following period, namely, the 2014–2020 period examined in this paper. Those that place in the lower and average to lower quartiles of EU fund absorption in 2014–2020 are, to a significantly larger extent, those without funds or projects in implementation from the previous programming period (2007–2013). Communes from the upper quartile are also more likely to have projects in implementation. A previous analysis (Marin et al., 2022c) shows that white spots in the current programming period tend to occur in communes that did not receive EU funding in the previous programming period. In addition, regarding relationships with urban areas, communes from the medium upper quartile are more likely to be part of a FUA: "A functional urban area consists of a city and its commuting zone. Functional urban areas therefore consist of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city" (Eurostat, 2018).

Furthermore, rural localities that place in the upper quartile of EU funds absorption are from communes with no change or even an increase in population between 2014 and 2021. In contrast, current white spots tend to occur in communes that experienced a population decrease of more than 10% in the same timeframe. Furthermore, the size of the population registered in the census matters. Communes in the average lower quartile tend to be in rural municipalities with up to 5,000 inhabitants. For a correct interpretation of these data, it is worth mentioning that the computational method for absorption capacity, and therefore for placement in the various quartiles, involves the consideration of the locality population for each of the analysed years (in euro at constant 2010 prices per inhabitant) and, therefore, it does not consider the population as registered in the latest available census.

6. Discussion

The analysis results highlight the importance of the territorial dimension to examining the distribution of EU funds, as has also been revealed by prior research (Capello, 2018; Collins et al., 2017; Hochhholdinger et al., 2021; Kalfova, 2019; Komorowski et al., 2021; Maier et al., 2021; Milio, 2007; Nicholas, 2021; Weber, 2020). The objective of reducing regional inequalities is an intrinsic part of the EU's goals of promoting economic, social and territorial cooperation (Article 174 of the Treaty on the Functioning of the European Union). The same article mentions particular attention given to rural areas and regions that have been affected by "severe and permanent natural or demographic handicaps" (OECD, 2022).

This analysis highlights the importance of both organisational – fiscal capacity and previous experience with EU funding, as well as of environmental factors – abundance of resources within the larger environment (State Budget funding), spatial attributes (affiliation to a specific development region and to a specific functional urban areas), together with community level variables – population dynamics in 2021 compared to 2014 and level of locality's development. Absorption capacity is thus depending on several sets of factors within and outside the organisation, which ultimately influence its relationship with the overall funding environment currently available in Romania.

Affiliation with a specific NUTS 2 or NUTS 3 is used to differentiate the volume of absorbed EU funds. Although, as earlier stated, development regions are only statistical constructs, their importance in differentiating the EU funds absorbed by municipalities located in rural areas has been proven by this study. The importance of development regions will grow even further in the upcoming years. For the next programming period, namely 2021–2027, the programming of regional operational programs is specific to each development region (on December 2, 2022, four regional development programs have been approved by the European Commission for the development regions of the Northwest, South, Southwest and West (see MFE, 2022). The coordination of implementation of these regional-level programs, however, is not managed by a local public authority in Romania. Rather, at the regional level, intermediate-level organisations in the EU funding structure are represented by regional

development agencies, which represent funding structures that are organised similarly to those of nongovernmental organisations. Additionally, although the current study did not assess the quality of governance or other structural characteristics at the regional level, differentiation by this type of territory well aligns with the studies of Kersan-Škabić and Tijanić (2017) and Kalfova (2019). In Romania's case, longitudinal clusterisation at the NUTS 3 level ranging from east to the west is partially confirmed by these studies, but the two studies are not directly comparable. Our study takes into consideration the entire volume of funds, while the study previously conducted in Romania only analyses the funds from the Common Agricultural Policy (Maier et al., 2022). In our study, the counties from which rural municipalities with the highest volume of funds are more likely to come are indeed located in the Western part of the country, with the exception of Tulcea. Tulcea County presents a special case, as it is both a border county and a special program for developing local communities from the Danube Delta (integrated territorial intervention, or ITI Danube Delta, which is located in the South East development region). The rest of the counties identified by the current analysis, Bistriţa-Năsăud, Cluj, Harghita and Hunedoara, are located in the North West, West and Centre development regions.

Furthermore, the size of the budget and level of development also count in determining EU funding levels, which aligns with earlier research (Cyburt, 2014; Komorowski et al., 2021; Marin, 2014; Mirska, 2021), as do issues related to the demographic decline in parts of the examined rural areas, which was pointed out in Weber et al. (2020). The importance of lack of prior experience with EU funding to the case of 'white spots' is in line with earlier research regarding the earlier programming period, mostly in reference to rural municipalities.

Notwithstanding, EU funding policy has been advocated several times as an important pillar in addressing the needs of rural shrinkage areas (Weber et al., 2020). This study explicitly addresses this topic and opens up the debate for a similar analysis at the EU level. The analysed database provides improvement to the integration of all sources of EU funding, although a better differentiation among funding lines could render a more nuanced picture on this topic.

7. Conclusions and next steps

Spatial attributes of a commune, such as development region and county affiliation, can be used to differentiate levels of EU funds absorption. Furthermore, financial capacity, affiliation with a FUA, demographic decline, population size, and state budget fund or EU funds absorption in the previous programming period can also be used to account for statistically significant differences in the capacity of rural municipalities to attract EU funds during the 2014–2020 programming period. In Romania, rural municipalities with higher levels of absorbed EU funding are to a statistically higher extent in the Centre, North West, South West and West development regions, in communes with no change or even an increase in population between 2014 and 2021, in the highest quartile of fiscal capacity, and possessing previous experience on EU funding from the prior programming period. They are also likely to be in the counties of Bistriţa-Năsăud, Cluj, Harghita, Hunedoara, Mureş and Tulcea. Furthermore, communes from the medium upper quartile of EU funding tend to be more developed communes, part of a FUA and in the Central and Northeastern development regions. As all the data from the analysed programming period (2014–2020) will become available from the same information source (local budget execution reports), it is possible that these characteristics/groupings might yield different results. Moreover, it would be good to have a finer picture on the different allocations of EU funding, based mainly on the NUTS 2 dimension, to provide an improved contextualisation of results. This criterion might become more pronounced for the programming period of 2021–2027, as part of the EU funds are allocated in Romania through individual regional operational programs.

The study's results are derived from an extensive database including all available information on EU funding (2016–2021) for all rural municipalities in Romania. Consequently, its results can serve as a reliable source of information, which can, however, be revised as further updates on EU funding at the municipality level become available through the next batch of local budget execution reports. Notwithstanding, the latest population census conducted across the EU can provide better information on the diverse characteristics, challenges and needs of rural areas across the EU, especially following the pandemic and the currently unfolding war in Ukraine and coupled with increasing energy tariffs. Additionally, a qualitative approach to assessing the motivations for (not) entering EU funds competition and/or the 'soft side' of the internal organisational structure of 'success' municipalities can result in new insights with relevant guidance for both academics and practitioners.

This study contributes to the growing knowledge on territorial evidence and can be further used as a policy instrument to more closely examine the intervention tools embedded in EU funding policy. The final results from the selected program period can provide a different picture. Even under these circumstances, this study can be used as a way of exploring the improved coordination of policy interventions that ultimately benefit a larger spectrum of rural areas. The use of an open database and the study's analyses represent an invitation to, on the one hand, replicate the methodology used here in other EU countries, especially in rural areas, and, on the other hand, to use the available data as an extensive case study (with almost 3,000 localities) in one member state for which EU funding has only recently become available. From a systemic approach, the results highlight the view on the absorption capacity as the complex set of interrelationships of public organisations with the characteristics of the environment. The results of the analysis are valuable to the design of integrated place-based strategies for EU, national and local level stakeholders, with an ultimate goal of improving the quality of life for citizens living in rural areas.

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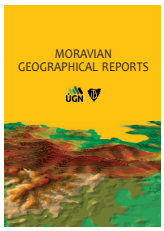
Appendix

Variable name	Variable description	Measurement unit	Data Source	Reference date/year	Source for data access
EU funds absorbed by each municipality	Sum of EU funds absorbed by each municipality in 2016–2021	Euro at constant 2010 prices per inhabitant	EU FAR database	2016–2021	Marin et al. (2022c) or ROHub (2022)
Fiscal capacity	Fiscal capacity computed by the author based on the average of own revenues – average value for 2016, 2017 and 2018	Euro at constant 2010 prices per inhabitant	MDLPA Annex 24 Local budgets execution	2018–2020	Ministry of Development, Public Works and Administration (2022)
EU funding in the previous programming period of 2007–2013	Information on implementation of EU funding from the previous programming period computed by the author based on local budgets execution database (if they reported or not expenditures under this budgetary chapter)	Binary variable (1-yes, 0-no)	MDLPA Annex 24 Local budgets execution	2016–2021	Ministry of Development, Public Works and Administration (2022)
Affiliation to a Functional Urban Area	Part of a Functional Urban Area. Recoded by the authors based on Eurostat data (Correspondence table LAU – NUTS 2021, EU-27 and EFTA / available Candidate Countries)	Binary variable (1-yes, 0-no)	Eurostat	2021	Eurostat (2023)
Presence of marginalised community at local level	Binary variable, based on The Atlas of Rural Marginalized Areas and of Local Human Development in Romania	Binary variable (1-yes, 0-no)	Teşliuc et al. (2016)	2011	Teşliuc et al. (2016)
State-Budget Funding	Information on State Budgets Funds in reference to PNDL2 allocations from 2018, as published by the Ministry of Development, Public Works and Administration	Binary variable (1-yes, 0-no)	MDLPA data	2018	Ministry of Development, Public Works and Administration (2018)
Population Dynamics in 2021 compared to 2014	Population dynamics as computed by the authors, based on the data from the National Institute of Statistics, Tempo online database	Several categories available[a]	National Institute of Statistics		Tempo online database (2022)
Level of development	Level of locality development as computed by professor Dumitru Sandu, open data available on citadini.ro	Several development categories available[b]	Citadini.ro		Citadini.ro
Development region (NUTS 2) and county (NUTS 3) affiliation	Affiliation of each locality to statistical development region or county	–	National Institute of Statistics	–	National Statistical Yearbook[c]

Appendix 1: List of variables

Notes: [a] Available categories: (i) decrease of more than 10%, (ii) decrease of less than 10%, (iii) no change or increase; [b] Available categories: (i) developed, (ii) getting out of poverty, (iii) in stagnating poverty, (iv) dynamic average developed, (v) stagnating average development, (vi) higher average dynamic development, (vii) missing information; [c] The source presents the grouping of localities into NUTS 3 and NUTS 2 in Romania and across Europe. "To meet the demand for statistics at a local level, Eurostat maintains a system of Local Administrative Units (LAUs) compatible with NUTS. These LAUs are the building blocks of the NUTS, and comprise the municipalities and communes of the European Union" (see: https://ec.europa.eu/eurostat/web/nuts/local-administrative-units)



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Spatial factors affecting the functional diversity of regenerated brownfields: The case of Silesian Voivodeship (Poland)

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Abstract

Until 1990, the Silesian Voivodeship was one of the most industrialised regions in Central Europe. The restructuring of the national economy after the change of the political system, in particular the extensive deindustrialisation, resulted in the emergence of substantial quantity of post-industrial brownfields. During the research we identified a total of 125 post-industrial brownfield sites that had undergone a regeneration process between 1990 and 2019. The total value of these regeneration projects was estimated at over EUR 1.7 billion. About 55% of the projects were carried out by public bodies, 40% by private enterprises and 5% by non-governmental organisations. The EU aid from structural funds was used in 37% of projects. The aim of the paper is to provide new empirical evidence about the role of spatial factors on the regeneration and new functional use of the brownfields. The analysis has revealed that there is a statistically significant relationship between the distance from the city centre and the functions of regenerated brownfield sites: commercial services were located closest to the centre, whereas manufacturing plants and investment zones were found at the greatest distance from the city centre. The research has also shown the crucial role of post-industrial heritage for projects related to redevelopment for public services, which was insignificant for other project types. These results have been interpreted in the context of the rent gap theory and the brownfield redevelopment potential model (the so-called ABC model).

Keywords: *post-industrial brownfield regeneration, rent gap theory, European Union aid funds, Silesian Voivodeship, Poland*

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1. Introduction

According to one of the most common definitions, brownfield is a term referring to

> "any land or premises which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilised. It may also be vacant, derelict or contaminated. Therefore, a brownfield site is not available for immediate use without intervention" (Alker et al., 2000, 64).

The term brownfield most often refers to post-industrial sites but may also include areas with other functions in the past, such as transport, military and even agricultural (Ferber et. al, 2006). In this paper, however, we decided to focus exclusively on the issues of the post-industrial brownfields due to limited data availability about other types of brownfield sites in Poland, particularly in the region chosen as the research area. The brownfield regeneration process can be defined as "the management, rehabilitation and return to beneficial use of brownfields" (Franz et al., 2006, 139). Redevelopment is a term often used as a synonym for regeneration (cf. Rey et al., 2022), but it seems to be more related to physical change in the use of space (Ferber et al., 2006). Remediation, in turn, is a term mostly used in an environmental context referring to decontamination of soils at brownfield sites (Alker et al., 2000). Built cultural heritage (or simply built heritage), another important term in the context of this research paper, refers to buildings, monuments, and structures of architectural and historical value, and is an important resource contributing to the cultural identity of residents (Tan & Ti, 2020). Finally, heritage reuse can be defined as a process undertaken to "to preserve the essential qualities and values of a heritage building while improving it to be used in the present and transferring it to the future" (Arfa et al., 2022).

Over the past two decades, several major research works, including governmental and international projects aimed at identifying success factors of brownfield regeneration processes, were implemented in order to support public policy in this field (e.g. English Partnerships, 2003; CABERNET, 2006; Ferber et al., 2006; Tölle, 2009; Osman et al., 2015; Longo & Campbell, 2017). Considering the spatial scale, the drivers and barriers of brownfield regeneration can be divided into three groups: general, location and site-specific factors (Frantál et al., 2013). The location factors, and among them the centrality of brownfield sites, are shown to be a significant driver of successful regeneration in some studies (Frantál et al., 2013; Osman et al., 2015; Longo & Campbell, 2017; Turečková et al., 2018, 2021; Preston et al., 2023). There is relatively little evidence, however, on how different new uses of regenerated brownfields are related to their proximity to the city centre: Frantál et al. (2015a) is one the few examples. Besides, the role of the cultural values of built heritage located on brownfields as a regeneration factor seems to be underrated and only recently has been analysed in depth (Szabó & Bozsoki, 2022).

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The aim of the paper is to answer the following research questions: First, is there a relationship, and to what extent, between the distance of completed brownfield regeneration projects from the city centre and the new use of the site? In other words: which of identified new uses of regenerated brownfields are likely to be located closer or further from the urban core, and which are independent from this factor? The second question relates to the post-industrial heritage, re-used as a part of a brownfield regeneration project: Is the new use of a regenerated brownfield site related to the presence and cultural value of these resources? The key element of the research procedure is the interpretation of the results in the context of the rent gap theory and the brownfield redevelopment potential model (so-called ABC model).

2. Theoretical background

The literature on brownfield regeneration can be divided into 4 main thematic groups: (1) brownfield redevelopment potential; (2) factors affecting redevelopment for a specific new use; (3) analysis and evaluation of regeneration effects; and (4) proposals of regeneration management tools. Firstly, however, rent gap theory, which was not developed specifically in the context of brownfield regeneration but plays an important role in interpreting the results of this paper, will be discussed here.

2.1 Rent gap theory

Rent gap theory was originally built to explain the redevelopment process of housing stock in city centres as a part of the gentrification phenomenon (Smith, 1979). It can also be helpful in understanding the motivations of developers to re-develop post-industrial brownfields, however, for various residential uses.

The key terminology, on which the theory is based, includes four definitions: house value (or generally property value); property sale price; capitalised ground rent; and potential ground rent. House value is measured by the quantity of socially necessary labour power required to produce it, taking into account its rate of depreciation through use, as well as its rate of appreciation through the addition of more value. The sale price reflects not only the value of the house, but also an additional component for rent since the land is generally sold along with the structures it accommodates. Whereas the ground rent is commonly defined as a claim made by landowners on users of their land, the capitalised ground rent is the actual quantity of ground rent that is appropriated by the landowner, given the present land use. The potential ground rent is, in turn, the amount that could be capitalised under the land's "highest and best use", which means, usually due to location, that such an area may be able to capitalise higher quantities of ground rent under a different land use than the present one. The

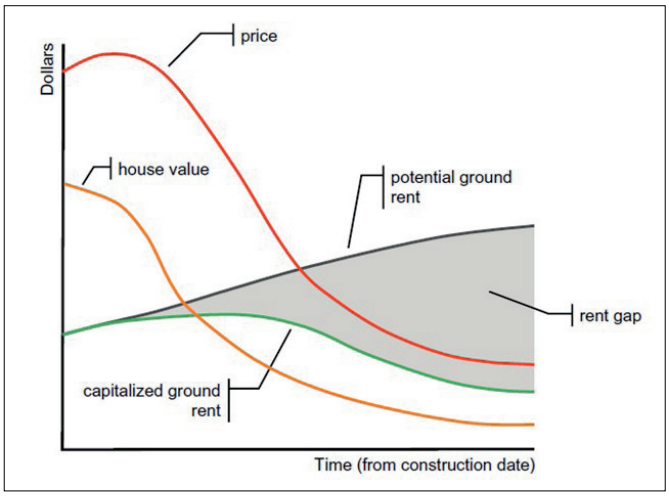

Fig. 1: The rent gap theory
Source: Diappi & Bolchi (2008, 9)

rent gap is the disparity between the potential ground rent level and the actual ground rent capitalised under the present land use (see Fig. 1). It is generated primarily by capital depreciation (which diminishes the proportion of the ground rent able to be capitalised) and by continued urban development and expansion (which has historically raised the potential ground rent level in the inner city). Only when this gap emerges can redevelopment be expected since if the present use succeeded in capitalising all or most of the ground rent, little economic benefit could be derived from redevelopment (Smith, 1979; Clark, 1995; Darling, 2005; Diappi & Bolchi, 2008; Lees et al., 2008; Slater, 2015).

2.2 Brownfield redevelopment potential

The key role in the classification of the economic potential for redevelopment of brownfields plays a model created for the UK government by the National Regeneration Agency (English Partnerships, 2003), which became the basis for the so-called ABC model (Franz et al., 2006). The main idea behind this concept is to divide brownfield sites into three categories based on the estimated cost of redevelopment and the potential value of new land use: (A) suitable for redevelopment based on the market rules without public intervention; (B) requiring public intervention or funding through public-private partnerships; and (C) unsuitable for any economically viable redevelopment (CABERNET, 2006; see Fig. 2). It should be noted, however, that this model has a dynamic character, as the actions of public authorities resulting in a reduction of the redevelopment cost or an increase in the expected value may contribute to a change

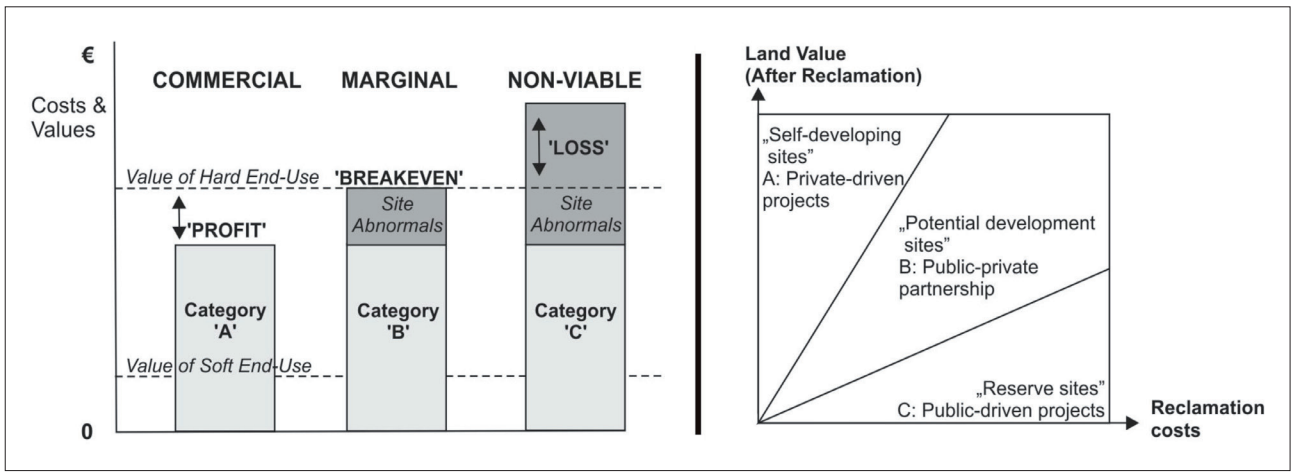

Fig. 2: Left: The Cabernet ABC Model
Source: Franz et al. (2006, 138). Right: The ABC model –brownfield redevelopment financing models (Source: Doleželová et al. (2014, 35)

in the classification of a given area to a more favourable one (English Partnerships, 2003). Considering the weaknesses of this model, Franz et al. (2008) note that in some cases parts of one brownfield site can belong to different categories; furthermore, a redevelopment of one part can involve re-categorisation of the remaining area. These authors also propose a further development of this model by adding a fourth D-category, covering areas that cannot be redeveloped even by the public sector, for which a possible scenario is natural succession. Doleželová et al. (2014) argue, that the practical usability of the ABC model may be limited, as in reality public subsidies are often directed to projects implemented in commercially attractive areas (category A), which limits the redevelopment opportunities for areas with little or no potential to attract private investment (categories B and C). Vojvodíková et al. (2021) note, that even though the ABC(D) classification model is widely accepted by experts, there are no universal criteria for assigning a given brownfield to an appropriate category. Therefore, these authors propose to base the categorisation on an assessment whether there is no obvious obstacle to redevelop a brownfield site (A), there is a barrier that can be removed within a few years (B), there is a significant barrier that precludes the site from redevelopment (C), or the site poses a danger resulting from contamination or degraded buildings (D) (cf. Vojvodíková et al., 2021, 4).

Regarding the location-related factors affecting brownfield redevelopment potential, Franz et al. (2006) only briefly mention 'wrong' location as a barrier to sustainable regeneration. Frantál and colleagues (2013) associate the impact of location with a local development potential or the area competitiveness, being the resultant of environmental conditions, economic potential, and social capital. These authors classify the location issues as meso-level factors, including transport links, the socio-demographic structure of local populations, economic potential, rates of unemployment and business activities, social capital et cetera (see Frantál et al., 2013). Further studies emphasise the importance of proximity to railway lines, support of local government and the removal of contamination before the start of an investment (Osman et al., 2015), the threat of the risk of environmental burden related to former functional use (Novosák et al., 2013), or unemployment and depopulation in the neighbouring area (Tintěra et al., 2014), as well as the demand for real estate of a given type and appropriate planning regulations (Frantál et al., 2015a).

Apart from the location issues, the site-specific factors affecting the redevelopment potential of brownfields should be considered. Frantál et al. (2013) mention both the physical aspects of brownfield sites (size, original use, buildings and structures, contamination, infrastructure) and those of a socio-economical nature (ownership relations and property price). Some of them are believed to be universal in nature, e.g. complex ownership structure and environmental burden leading to higher redevelopment costs (Frantál et al., 2015b). The remediation costs, however, may be difficult to predict before the beginning of the process (Kurtović et al., 2014). The barriers also include excessive duration of the period from the end of the original industrial activity to the decision to redevelop the brownfield, resulting in various forms of temporary land use (Johnson et al., 2009), and the asymmetry of information disadvantageous for potential investors (Trouw et al., 2020). Besides, the negative image of brownfields is mentioned as a constraint to redevelopment, but it can be overcome thanks to a pioneering approach of certain developers (Krzysztofik et al., 2013). Other identified site-specific barriers include uneven topography, irregular plot shape, and water bodies (Preston et al., 2023). The success factors in the completion of already started projects are the involvement of all stakeholders (Rizzo et al., 2015), particularly the local community (Lehigh et al., 2020), the level of income of local residents and the share of green areas in the designed land use (Green, 2018), as well as good management in the public sector, especially in less developed regions with lower investment attractiveness (Klusáček et al., 2018).

2.3 Factors affecting brownfield redevelopment for a specific new use

The research to date (Frantál et al., 2015a) demonstrates that the central location of a brownfield and its good transport connections are positively correlated with redevelopment into commercial facilities and offices, and negatively with the redevelopment for housing and public services. The preferences of residents are also of great importance, who, according to the research, value functionality more than the aesthetics of completed projects (Martinát et al., 2018), and the further the area is from the city centre, the stronger the preference for recreational functions (Navrátil et al., 2018). Researchers have also identified a pattern according to which transformations into a recreational function prevail in the case of the largest facilities, including such specific ones as mine dumps, disused settling ponds or landfill sites (Pytel et al., 2021). Moreover, the redevelopment of brownfield areas for recreational purposes is favoured by the public ownership of land and location in the vicinity of residential districts (Siikamäki & Wernstedt, 2008), and the main barriers are the weaknesses of spatial policy (Kristiánová et al., 2016). Redevelopment of brownfields for recreational purposes is also considered to be more acceptable by local communities than commercial ones (De Sousa, 2003), but due to the lack of generated income, they require securing funds not only for the investment process, but also for future maintenance (Doick et al., 2009; Krzysztofik et al., 2020). In turn, regarding housing development, it is noted that due to the higher cost of brownfield site preparation, in order to be profitable, developers must increase the intensity of development, which should be included in the local development plans (Karadimitriou, 2013). The potential of using public-private partnership in the development of housing investments is also emphasised, subject to the need for the interests of both sectors to be aligned, as well as public ownership of the land and the participation of an academic institution (Lia et al., 2016).

2.4 Evaluation of brownfield regeneration effects

When analysing the effects of regeneration projects, much attention is paid to the assessment of their compliance with the principles of sustainable development, both in the environmental (Franz et al., 2006; Pediaditi et al., 2010) and social aspect (Dixon, 2007; Glasson & Wood, 2009). What is important is that sustainable development in terms of nature does not force brownfield areas to be transformed only into green space, because also redeveloping them for other functions allows a reduction in the consumption of greenfield areas (Franz et al., 2006). Researchers have identified measurable benefits in this regard using the example of Luxembourg, where the regeneration of 550 ha of brownfields allowed avoiding expansion into uninvested land equivalent to the area previously consumed by the city over a period of three years (Glumac & Decoville, 2020). On the other hand, in terms of economic issues, it is emphasised that although redevelopment from public funds does not generate jobs or an increase in property tax revenues as private investments, it brings benefits for residents in the social, health and environmental aspects (Kotval-K, 2016). Regarding the recreational function, attention is drawn to the risk of an increase in housing prices in the area (Noh, 2019), and the threat to human health in the event of improperly conducted remediation (Pecina et al., 2021), which might also apply to housing investments (Squires and Hutchison, 2021). The application of the threshold analysis method, in turn, allowed one to recognise the regularity that only after exceeding the "critical mass" of the office space in the brownfield area, the prices of apartments in the area began to rise sharply (Tang & Wong, 2021).

2.5 Proposals of regeneration management tools

Justifying the use of brownfield regeneration management tools for managing the brownfield regeneration process, researchers point to the need to improve decision-making processes, which should focus on delivering measurable benefits (Atkinson et al., 2014). The concepts include both tools based on multi-criteria analysis (Schädler et al., 2011; Rizzo et al., 2018), as well as those operating within GIS spatial information systems (Beames et al., 2018). Hammond et al. (2021) made a critical review of the instruments used, pointing to their weaknesses: insufficient use of quantitative socio-economic criteria, a tendency to focus on later stages of regeneration, an underdeveloped user interface and negligible use of forecasting models. Chen & Young (2022) propose a Brownfield Redevelopment Query (BRQ) model aimed at converting environmental, economic, and social impacts into the benefit-cost ratio (BCR) as a unified evaluation benchmark, considered in the scenarios of site redevelopment for residential, industrial, commercial, or public services use. Preston et al. (2023) developed a brownfield hierarchical typology based on the proportion of impervious land cover, landscape metrics (size, slope, shape indicators, etc.) and mean land cover distribution, to assess their potential to contribute to urban ecosystem services and green infrastructure.

Summing up the theoretical aspects, according to rent gap theory discussed above, the redevelopment potential of a brownfield is related to the gap between the current ground rent and the potential rent after the change site use to a possibly most effective one. This concept, however, does not consider factors other than proximity to the city centre, which may affect the potential ground rent, nor does it consider the necessary redevelopment costs. In the light of the ABC classification model, the potential of some brownfield sites resulting from both location and site-specific factors discussed above (e.g. good condition of buildings and structures that can easily be adapted for new use, low pollution, limited conservation restrictions, ownership structure) is so high that their redevelopment is possible without public intervention (category A). Some brownfields, due to various constraints, can be redeveloped only with the substantial support of public funds (category C). As shown by the international experience in the field of post-industrial brownfields regeneration – their return to beneficial use by private companies is possible provided that the investment is supported by public entities (category B). Even though the general concept of this model is quite commonly acknowledged, there are no universal criteria of categorising brownfield sites by their redevelopment potential. The significance of location issues was demonstrated in a number of the research works discussed above; but some studies suggest a greater importance of other site-specific or general factors. Furthermore, there is not enough evidence of the relation between the centrality of a brownfield site and its suitability for redevelopment for a certain use. Besides, the role of the cultural value of built heritage seems to be underrated among other site-specific factors. In this paper, we are trying to contribute to a discussion regarding the above-mentioned gaps.

3. Data and methods

Silesian Voivodeship is one of 17 Polish regional administrative units (NUTS 2). It is located in southern Poland covering an area of 12,333 km^2. With a population of 4,375,947 (in 2021) and population density of 355 inhabitants per km^2, it is the most densely populated voivodeship in the country, and with 76% of the population living in urban areas – also the most urbanised. The largest cities are Katowice, Częstochowa and Sosnowiec – with 283, 211 and 192 thousand residents respectively in 2021 (Statistics Poland – Local Data Bank, 2022). This region was chosen as the study area because until 1990 it was one of the most industrialised regions in Poland, in the field of coal mining, metallurgy and energy, and to a lesser extent also the automotive and textile industry. Consequently, the restructuring of the national economy after the change in the political system, in particular the extensive deindustrialisation, resulted in the emergence of substantial quantity of post-industrial brownfields. In the first quarter of 2020, an inventory was carried out to identify possibly all brownfield regeneration projects that were completed between 1990 and 2019. The collection of data on the regeneration of post-industrial brownfields, that lost their original functions after 1990 and were redeveloped for new uses, was carried out using and reviewing the following sources:

- Scientific publications on regeneration and history of post-industrial brownfields in Silesian Voivodeship.
- Internet article databases of national (Gazeta Wyborcza, 2020) and local press (Dziennik Zachodni, 2020) based on keywords related to the brownfield regeneration process;
- Database of projects co-financed from EU aid funds in the programming periods 2004–2006, 2007–2013 and 2014–2020, based on keywords related to the brownfield regeneration process (Grants Map EU, 2020);
- Database of sites on the Industrial Monuments Route of the Silesian Voivodeship (2020);
- Database of industrial and technology parks published by the Polish Investment and Trade Agency (2020); and
- Database of urban regeneration projects of the Silesian Association of Municipalities and Counties (2020).

Additionally, a review and an update was carried out regarding the information on the projects of regeneration of post-industrial brownfields identified in the 2010 study on the impact of post-industrial brownfield regeneration on the labour market in Silesian Voivodeship (Jarczewski & Huculak, 2010). The data collected comprise of location of brownfield regeneration projects, the regeneration costs including share of public support, type of new use, size of redeveloped area, number of jobs created, and value of cultural heritage located on brownfields and reused within the projects. For the analysis, it was decided to choose the type of new use as the dependent variable, and the location as well as the value of cultural heritage as independent variables. The quantitative data and coded qualitative data were analysed using descriptive statistics, the normality of the distribution was verified by the Shapiro-Wilks test, and the statistical difference between the variables was verified by the Kruskal–Wallis test.

The new uses of regenerated brownfields were aggregated into four categories, based on the classification of Chen and Yang (2022): public services (cultural, educational, and recreational facilities); commercial services (retail facilities, offices and hotels); manufacturing/investment zones; and housing. The basis for identification of city centre locations was the National Register of Boundaries published by the Head Office of Geodesy and Cartography (2020). In the process of verification, the market square was considered the central point of the city. In the absence of a market or a central square, the functional centre of gravity of city-forming services was considered as the central point, based on the search of internet sources and analyses of the city structure. The distance between each regeneration project and the city centre was measured as a straight-line distance using GIS tools. Regarding the value of cultural heritage included in the brownfield regeneration projects, the projects were coded basing on a rating of 3 to 0 points: 3: sites entered into regional register of historical monuments or belonging to the Industrial Monuments Route; 2: buildings and structures included in the municipal register of historical monuments or erected before 1945; 1: buildings and structures erected after 1945 integrated into an older, historical spatial arrangement; 0: no cultural heritage involved in the project.

4. Results and discussion

4.1 Structure of completed brownfield regeneration projects

As a result of the study, 125 post-industrial brownfield regeneration projects were identified, which are predominantly located in the central, most urbanised part of the region (see Fig. 3). The total value of these projects at the end of the first quarter of 2020 amounted to PLN 7.4 billion (Tab. 1), which was then approximately EUR 1.6 billion.

In terms of quantity, the largest group consisted of brownfield sites with various uses related to public services. Almost all these projects were implemented by public entities (mainly local governments), and the vast majority obtained funding from EU aid funds, mainly from the European Regional Development Fund (ERDF). The second largest group of ventures were commercial projects carried out exclusively by private entities, basically without the support of public funds. It should be noted, however, that the average project value in this category was approximately

New use	Number of projects	% of total number	Estimated value of the projects (million EUR)	% of total value	Average value per project (million EUR)
Public services	40	32.0	209	12.9	5
Commercial services	38	30.4	954	58.9	25
Manufacturing/investment zones	38	30.4	370	22.8	10
Housing	9	7.2	88	5.4	10
Total	125	100.0	1,621	100.0	13

Tab. 1: The number and value of post-industrial brownfield regeneration projects in Silesian Voivodeship by new use
Source: authors' research and calculations (as of March 31, 2020)

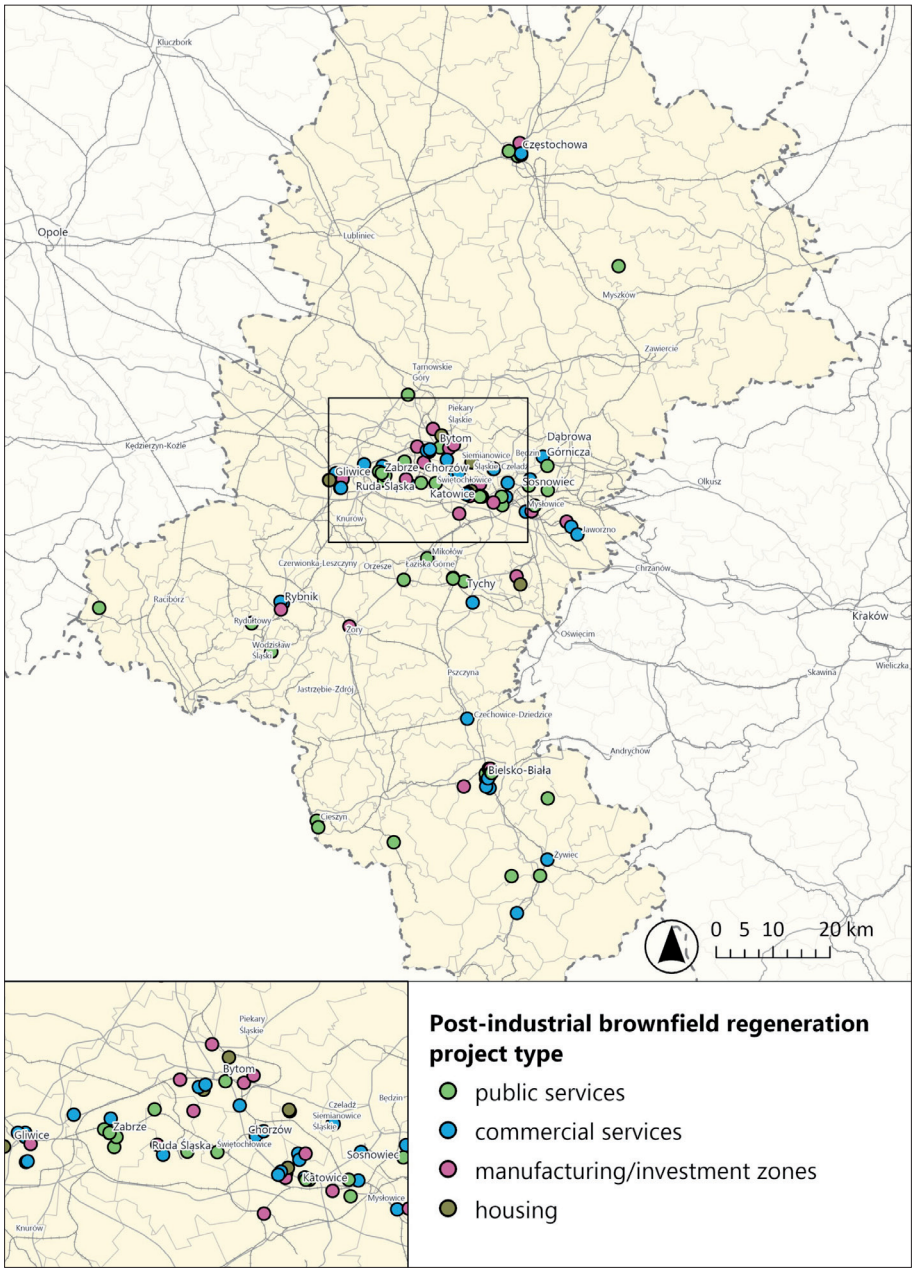

Fig. 3: Distribution of post-industrial brownfield regeneration projects by type of new use
Source: authors' elaboration using their research project findings

five times higher than in case of public services, thus the value of these commercial regeneration projects amounted to almost 59% of all projects' total value. Post-industrial brownfields were also often used to create various types of investment zones aimed at supporting local economic development, and in some cases redeveloped for new industrial activities. These projects, covering ca. 23% of the total value, are a field of interaction between public entities, active at the stage of remediation and infrastructure improvement, and private investors, redeveloping the site for economically viable use. It is worth paying attention to the relatively small number of housing projects – only nine development projects were identified (see Fig. 4), which is related to a relatively weak housing property market in the region resulting from depopulation. More specific characteristics of analysed projects are listed in Table 2.

It is worth emphasising that more than 60% of the projects take advantage of the cultural heritage resources, which is related to the importance of these sites for building local identity of the inhabitants. A very similar share of the projects belonged to an implemented regeneration programme, what means they contributed to the complex regeneration of a larger urban area. Non-public entities, including private capital and NGOs, are altogether responsible for less than one half of the implemented projects. This phenomenon will be discussed further based on the rent gap theory and models of brownfield redevelopment potential. Nevertheless, the fact that more than one third of the projects were supported by the EU aid funds strongly indicates the substantial role of external financing in initiating the regeneration process of brownfield sites.

Characteristic of brownfield regeneration projects	Share of the total number of projects (%)
Preserving and exhibiting elements of material cultural heritage	61
Comprehensive redevelopment of the entire post-industrial area (completed regeneration)	60
Implementation by private capital	40
Co-financing by the ERDF	37
Implementation by non-governmental sector	5

Tab. 2: Selected characteristics of brownfield regeneration projects (overlapping categories – not summing up to 100%) Source: authors' elaboration – as of March 31, 2020

Fig. 4: Housing development located on regenerated brownfield – former spoil tip in Chorzów. Photo: J. Koj

4.2 The role of legal system in the post-industrial brownfield regeneration process

The regeneration of post-industrial brownfield sites basically meets the objectives set for urban regeneration in Poland (leading a certain area out of the crisis), and at the same time has been legally marginalised. The Polish Regeneration Act[1] clearly indicates that, in principle, the subject of regeneration should be residential areas, and "uninhabited" areas, including post-industrial brownfields may be included in the process only if they serve the inhabitants of neighbouring degraded areas.

Table 3 presents a list of projects for the regeneration of post-industrial brownfields which in the Silesian Voivodeship received the largest funding from the European Regional Development Fund. The impact of each of these projects on the inhabited area directly adjacent to the brownfield site may be considered insignificant, and in some cases, it would be very difficult to find any connections at all.

Such a legal requirement, although it does not exclude completely, may radically limit the possibilities of post-industrial brownfields regeneration supported by public funds. Only in very

[1] Art. 11. Paragraph 3 of the Regeneration Act of October 9, 2015: Uninhabited post-industrial brownfields, including former port and mining areas, military or railway brownfields, where negative phenomena exist, (...) may be included in the regeneration area only in the event when the activities that can be carried out in these areas will contribute to counteracting the negative social phenomena referred to in art. 9, sec. 1.

No.	Project name	New use	Name of the former industrial plant	Municipality	Project value (M€)	ERDF support (M€)
1.	Silesian Museum	museum	Katowice Coal Mine (previously Ferdynand)	Katowice	57	39
2.	National Symphony Orchestra of Polish Radio	concert/event hall	Gottwald Coal Mine (previously Eminencja)	Katowice	67	32
3.	Euro-Centrum Industrial Park	entrepreneurship support	Chemical Equipment Plant Wimach	Katowice	29	19
4.	Galena Shopping Mall	shopping mall	Jaworzno Coal Mine	Jaworzno	42	16*
5.	Nowe Gliwice	entrepreneurship support	Gliwice Coal Mine	Gliwice	22	8
6.	Stara Kablownia Shopping Mall	shopping mall	Silesian Cable Factory	Czechowice-Dziedzice	20	7*
7.	Silesia Industrial-Technology Park	entrepreneurship support	Wawel Coal Mine/ Polska Coal Mine	Ruda Śląska/ Świętochłowice	12	6
8.	Redevelopment of Water Tower in Zabrze at Zamoyskiego st. 2 for social, educational, scientific and cultural uses	museum	Water Tower	Zabrze	7	5
9.	Sosnowiec Science and Technology Park	entrepreneurship support	Niwka-Modrzejów Coal Mine	Sosnowiec	9	5
10.	GPP Business Park	entrepreneurship support	Spoil tip of the Silesia Zinc Works	Katowice	7	5
11.	Częstochowa Industrial-Technology Park	entrepreneurship support	Częstochowa Steelworks	Częstochowa	6	4
12.	Postindustrial Coal Mining Heritage Centre in Zagłębie	museum	Saturn Coal Mine	Czeladź	5	4
13.	Bytom Industrial Park	entrepreneurship support	Orzeł Biały Mine and Metallurgical Plant	Bytom	6	4

Tab. 3: Regeneration projects for post-industrial brownfields in Silesian Voivodeship with the highest value of support from the ERDF
*Notes: * Repayable support through JESSICA initiative*
Source: authors' elaboration based on Grants Map EU

specific situations, regeneration of post-industrial brownfields "counteracts negative social phenomena" in the neighbouring area. Usually, projects undertaken in such areas (shopping centres, business parks, museums, concert halls, new industrial plants) are targeted at much wider communities – residents of the city, region, and even international partners.

4.3 Relationship between the distance from city centre and the new use

Based on the analysed data, it is possible to indicate a statistically significant relationship between the distance from the city centre of post-industrial brownfield regeneration projects and certain new uses of the sites. The distances of the analysed projects from the city centre varied from 0.1 km to 11.1 km, with a mean value of 2.2 km and standard deviation of 1.9 km. The first, second (median), and third quartiles were 0.9, 1.6 and 2.7 km respectively. The results of the Shapiro-Wilk test performed ($W = 0.81$, $p < 0.001$) demonstrate a significant deviation of the distribution of the distances variable from the normal distribution. The statistical distribution of distances from the city centre of brownfield regeneration projects by new use are shown in Table 4.

The significant result of Kruskal-Wallis test together with post-hoc test, $\chi^2_{\text{Kruskal-Wallis}}(3) = 13.61$, $p = 0.004$, $\varepsilon^2_{\text{ordinal}} = 0.10$, $N = 125$, testified that distance from the centre was significantly lower for commercial services use than for the manufacturing and investment zones, $p_{adj} = 0.003$. Furthermore, no significant differences in the distance between other pairs of groups were found. A graphical representation of the distributions of distances from the centre for each group along with the test results can be found in Figure 5.

New use	Number of projects	Distances from the centre [km] (Median Q1–Q3)
Commercial services	38	1.57 (0.64–2.12)
Public services	40	1.41 (0.70–4.09)
Housing	9	1.57 (0.85–1.78)
Manufacturing/investment zones	38	2.21 (1.58–3.62)

Tab. 4: Distribution of distances of brownfield regeneration projects from the city centre by new use of the site. Source: authors' calculations

New use	Number of projects	Value of the cultural heritage (Median Q1–Q3)
Commercial services	38	0.0 (0.0–2.0)
Public services	40	3.0 (1.0–3.0)
Housing	9	0.0 (0.0–1.5)
Manufacturing/investment zones	38	0.0 (0.0–1.0)

Tab. 5: Distribution of the of the cultural value of industrial heritage by new use of the site. Source: authors' calculations

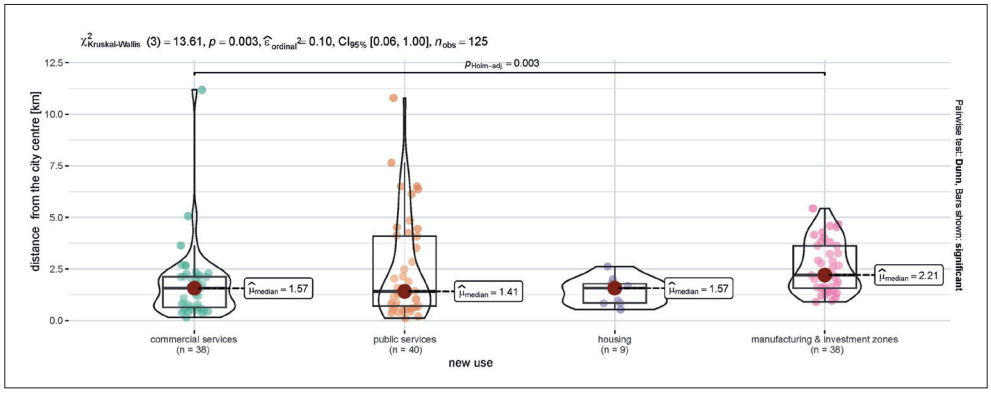

Fig. 5: Distribution of distances of brownfield regeneration projects from the city centre by new use of the site
Source: authors' elaboration

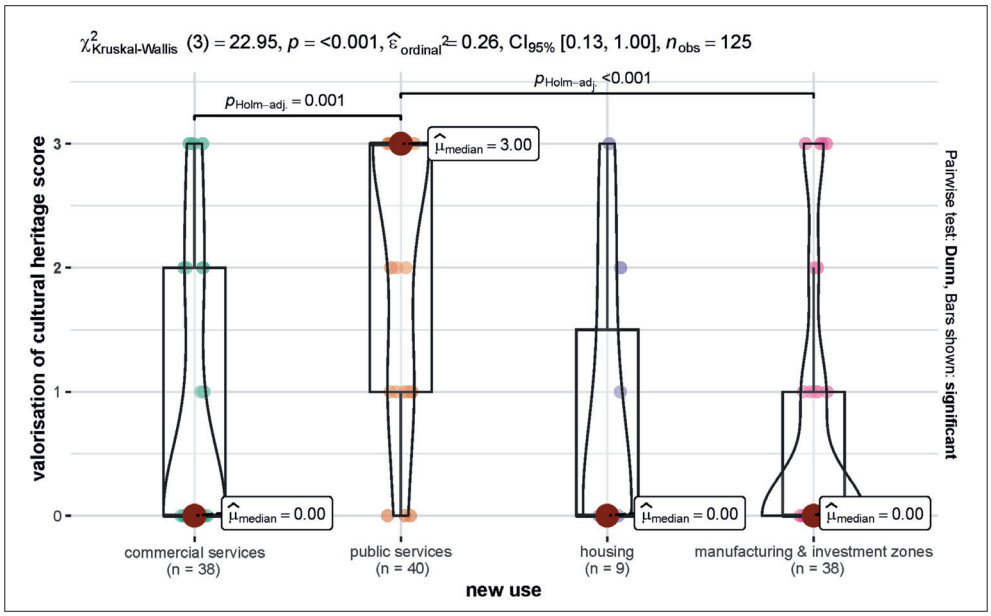

Fig. 6: Distributions of cultural heritage values by new uses, within test scores for between-group differences
Source: authors' elaboration

4.4 Relationship between cultural values and the new use

Apart from the impact of the project's location on the new use of the site, a relationship between the cultural value of built heritage involved in the regeneration process and the new use was also found. The mean value of cultural heritage according to the applied rating scale was 1.13 with a standard deviation of 1.26. The significant results of the Shapiro-Wilk test proved that the value of cultural heritage was characterised by a significant difference from the normal distribution. The distributions of the measures of central tendency together with the measures of the position of the cultural heritage value by new use of the site are presented in Table 5.

The significant result of Kruskal-Wallis, $\chi^2_{Kruskal-Wallis}$ (3) = 22.95, $p < 0.001$, $\varepsilon^2_{ordinal} = 0.26$, $N = 90$, together with Dunn's post-hoc test, showed that value of cultural heritage was significantly higher for public services use than for commercial services, as well as for manufacturing and investment zones. For a graphical representation of cultural heritage value by the new use of brownfield site, see Figure 6.

The trends presented in Table 3 and Figure 4 can be partially interpreted in the context of the rent gap theory (see Fig. 1). As discussed above, rent gap is the difference between the current land rent obtained with the current use of the land and the potential rent expected with new, more profitable use. According to this theory the attractiveness of vacant land suitable for redevelopment is determined by the size of the gap, which reflects the expected profits from the investment. In the immediate vicinity of city centres, the greatest profits would come from investing in commercial services, i.e. office buildings, retail facilities and hotels, and the areas which are most distant from city centres would be profitable to use for new industrial plants and investment zones.

The urban land rent model is not able to explain all projects related to regeneration of post-industrial brownfields, however, because some of the actors actively involved in spatial development are public bodies, in Polish conditions most often state or local government. These bodies, when implementing brownfield regeneration projects, most often follow goals other than maximising profit while minimising costs. These are, among others, the need to preserve and exhibit the cultural heritage (museums, galleries), creating public utility buildings important for local communities (schools, sports and recreation facilities, cultural institutions, and conference rooms), creating space necessary to support local entrepreneurship etc. An example of the regeneration preserving the historical-cultural heritage is the project of the contemporary art gallery in the complex of former coal mine and power plant in Czeladź city (see Fig. 7).

Therefore, apart from the rent gap theory, the research results must also be interpreted in the context of the so-called ABC model (Fig. 2), according to which the redevelopment of a given brownfield site also depends on the costs necessary to start a given activity The potential of some sites (e.g. location, good condition of buildings, low contamination, limited conservation restrictions, ownership structure) is so high that their redevelopment is possible without public intervention (category A). Some brownfield sites, due to various constraints, can be redeveloped only with the substantial participation of public funds (category C). As shown by the international experience in the regeneration of post-industrial brownfields, in many cases their redevelopment by business partners is possible provided that the investment is supported by public entities (category B).

The commercial (market) use of post-industrial brownfields requires that expenditures on regeneration, included in the total costs of an economic venture, should not be a barrier to achieving a satisfactory profit for the investor. This situation is basically possible in two cases:

a. the economic activity planned in the regenerated area will bring income that will allow the investor to generate an appropriate profit in the planned period; and
b. a part or all the costs related to regeneration will be financed from public funds, reducing the total costs of the project to the level acceptable to the investor.

5. Conclusions

As a result of this research, it was found that there is a relationship between the location of a post-industrial brownfield regeneration project and the new use of the site. Statistically significant differences were observed only between certain uses, however, e.g. commercial services were located considerably closer to the city centre in comparison to manufacturing plants and investment zones. For other identified uses of regenerated brownfields, e.g. public services and housing, no significant

Fig. 7: Contemporary art gallery called "Power Plant" in the former coal mine complex in Czeladź. Photo: J. Koj

relationship was observed. As discussed above, the applicability of the rent gap theory to explain this phenomenon is limited due to two constraints: first, it focuses on redevelopment processes initiated by private investors; second, it considers only potential profits of new use without considering the redevelopment costs. Therefore, we propose a modification of this model, in which the rent gap would be reduced by the required investment expenditure capitalised over the project's lifetime at a given interest rate. It would then reflect the real potential profitability of the redevelopment for a new use by a private investor, or in case the projected costs exceeded the potential benefits – the amount of necessary public support.

The results have also showed a connection between the cultural value of built heritage located on a regenerated post-industrial brownfields and new use of the site. Public services were developed on brownfields with significantly more valuable built heritage than commercial services or manufacturing plants and investment zones. Only for projects related to housing development was no significant relation observed. Therefore, it can be concluded that valuable heritage resources can be either an important driver or a barrier to brownfield regeneration, depending on the intended new use. In this context, we propose a modification of the ABC model, which should include, in addition to the economic value already considered, also the cultural value of brownfields related to their built heritage. We believe that for certain new uses (e.g. museums, galleries, hotels, restaurants) the cultural value should be considered as a factor increasing the redevelopment potential of brownfield sites, in some cases compensating for higher costs necessary to be incurred by the investor.

Based on the example of this study area, it is impossible to ignore the role of industrial heritage preservation and reuse for the local communities. The importance of this issue is evidenced by the creation and development of the Industrial Monuments Route of the Silesian Voivodeship, the first of its kind in Poland, with 40 sites in nearly 30 municipalities as of April 1, 2021. Before the pandemic, the last edition of the festival of this route named Industriada attracted over 100,000 participants (Industrial Monuments Route of the Silesian Voivodeship, 2022). Other examples of how important the fate of post-industrial heritage is for the inhabitants, are the Zabrze authorities' efforts to recognise the most valuable historical colliery complex in the city as a National Historical Monument, as well as the application of a local NGO taking care of the historic silver and lead mine in Tarnowskie Góry to the World Heritage Committee – in both cases successful.

The regeneration of post-industrial brownfields in this study area was carried out mostly at a distance not exceeding 2.7 km from the city centre (75% of the projects). It is then one of the ways of strengthening the regeneration processes outside the strict city centre, but still within the inner-city area. Thereby, it might contribute, albeit to a limited extent, to mitigating the effects of the crisis of city centres resulting from depopulation and changes in the way that residents spend free time. The process of regeneration of post-industrial brownfields involves significant private funds (ca. 40% of the projects, amounting to ca. 60% of total regeneration costs of all analysed projects), but, nevertheless, often also requires public support. This applies in particular to those projects that are preserving and reusing tangible post-industrial heritage. Unfortunately, the provisions of the Polish Regeneration Act significantly limit the possibility of including such projects in publicly supported urban regeneration programmes. As a result, they not only can possibly have worse access to EU aid funds, but also in the minds of local authorities and inhabitants it may be difficult to build the awareness of importance and urgency to redevelop such sites. Therefore, we would recommend a public policy to consider the issues of disadvantageous location of brownfield sites and the high cultural value of their built heritage as factors favouring public financing. We believe that this approach would be more effective than the requirement to counteract negative social phenomena, currently included in the Polish Regeneration Act, which in many cases may be difficult to prove and evaluate.

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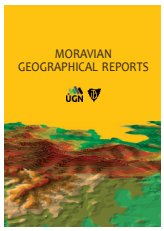

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Gender differences in unsafety perception and precautionary behaviour among adolescents: Case study of a small peripheral town in Slovakia

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Abstract

The aim of this study is to question gender stereotypes regarding differences in the unsafety perceptions and perceived threats of adolescents, with a special emphasis on their precautionary behaviour. This research was based on emotional mapping in the very small peripheral town of Fiľakovo (Slovakia). Altogether, 151 adolescents in the age of 10–16 years were asked to mark places where did not feel safe, along with perceived threats, as well as information on precautionary strategies they use there. Regardless of the time of day, neither girls nor boys felt significantly less safe, with residential location and age playing a more important role in unsafety perception differences than gender. Girls perceived significantly more people-related threats than boys (regardless of daylight), while boys were aware of significantly more risk in buildings, streets, and places with negative associations (after dark). Avoidance, dependence, and self-reliant precautionary behaviours were identified. Regardless of daylight, girls chose dependence (e.g. calling someone, having a companion) among other types of precautionary behaviour significantly more often than boys. Avoidance and self-reliance were gender neutral. The perception of girls as perceiving more risks and being more avoidant is showed to be a form of gender stereotype and should not be considered a generally valid paradigm.

Keywords: *adolescents, safety perception, risk management strategies, constraint behaviour, gender, Slovakia*

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1. Introduction

Research to date has shown that gender is one of the most important unsafety perception predictors (Mak & Jim, 2018; Soto et al., 2022). In general, women and girls feel more insecure in public spaces than men and boys (Johansson & Haandrikman, 2021; León et al., 2022; McCray & Mora, 2011; Skår, 2010), and are considered more vulnerable by their relatives (Hatamzadeh et al., 2017; Osman & Jíchová, 2019; Vozmediano et al., 2017). As a result, such concerns may discourage women from using public spaces equally to men (Carver et al., 2010; Soltani & Zamiri, 2011; Tandogan & Ilhan, 2016). Such an effect occurs even though women are actually less likely to experience victimisation than men (May et al., 2010).

Yet, some studies have found that the dichotomy based on fearful women and fearless men is too simplistic – for instance, the gender differences in unsafety perceptions can change over time and space and due to perceived threats (Johansson et al., 2012; Pánek et al., 2017; Rišová & Sládeková Madajová, 2020) or crime type (Chataway & Hart, 2019). The complexity of this problem has not been sufficiently explored, especially in the case of adolescent girls living in small-scale settlements, which are generally neglected in fear-related studies. Unsafety perception research focusing on gender differences in the case of younger adolescents (up to 15 years old) is limited and, to our knowledge, that pertaining to constrained behaviour is non-existent. For example, a limited number of adolescents (nine) took part in a study by Van der Burgt (2015), yet the participants were 16 to 19 years old. Similar research involving slightly younger participants (with a mean age of 15) was carried out by Krulichová and Podaná (2019), although this provided no information regarding details on the precautionary strategies of adolescents, only the result that girls apply avoidance behaviour more often than boys.

To address this research gap, this study presents results pertaining to younger adolescents (with a mean age of 12.81). The aim of this study is to analyse gender differences in the unsafety perceptions of adolescents living in a very small town, with a special emphasis on the temporal variations in unsafety perceptions, perceived threats, and precautionary behaviours, which, according to some authors can be defined as the activities people do to protect themselves from crime and reduce their risk of victimisation (Krulichová & Podaná, 2019; May et al., 2010), while others mention precautionary actions and strategies in

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connection with the response to fear or an attempt to reduce it (Doran & Burgesss, 2011). Our study is based on the paradigm that teenagers are not passive but "actively negotiate risk and promote safety in public space and are active – as well as socially and spatially competent – agents in their everyday lives" (van der Burgt, 2015, 193). The research questions were formulated as follows:

- Are there any significant gender differences in unsafety perception? If so, do they vary according to the time of day?
- Are there any gender differences in threat perception? If so, do they vary according to the time of day?
- Are there any differences in precautionary behaviours applied in areas perceived as unsafe by girls and boys? If so, do they vary according to the time of day?

Additionally, there is also a research gap pertaining to the geographical study area selection. Unsafety perception studies have so far focused on medium- to large-sized cities (with the exception of e.g. Jakobi & Pődör (2020) who examined also towns with a population of 10–20 thousand inhabitants, but with only adult participants involved). In order to obtain complex knowledge on unsafety perceptions, there is a need to conduct studies in various types of urban as well as rural environments, and with various morphological structures, transport systems, and social conditions.

2. Theoretical Background

In the 1990s, the reasons why women are more afraid in public space than men began to be discussed from two main perspectives: the traditional and feminist viewpoints. The first one explained the differences as due to women's overall tendency to be fearful more than men. For example, a well-known study pertaining to the gender differences in fears and phobias by Fredrikson et al. (1996), found that women struggle with fears and phobias more often not only in general, but also when looking at some specific phobias, including that of the darkness. Yet, the discussion has been primarily focused on the fear of crime while omitting other types. According to the feminist approach, women feel less safe since in public spaces, which are subordinated to patriarchal principles, they are objectively threatened more often. There, due to social constructs, women face dominant masculinity (Hanmer & Saunders, 1993; Mehta, 1999; Stanko, 1990) and, in some cases, misogyny (Bhattacharyya, 2015). In addition, due to having a biological predisposition for a smaller and weaker figure, they are less likely to defend themselves (Hale, 1996).

Another discussion has pertained to the fact that women, despite being objectively less likely to be victimised compared to men, report fear of crime more often (Ferraro, 1996; Jacobsen, 2021). This discrepancy, the so-called gender-fear paradox, has been explained by several hypotheses. The most often mentioned is the "shadow of sexual assault" hypothesis, which is based on the theory that women's fear of sexual assault increases other fears, especially those of personal assault, as fear of crime is often perceived in connection to fear of rape (Ferraro, 1996).

Other possible explanations for the gender-fear paradox are based on social constructs and gender stereotypes. From a young age, girls are socialised differently to boys, which leads to a belief in their own vulnerability and inability to face potential threats in public spaces. Parents and peers are the most important contributors to gendered socialisation (Kĺgesten et al., 2016), but educational institutions (Bhattacharjee, 2021; Chen & Rao, 2011), the media (Kang & Hust, 2022), and gender-typed marketing (Lipowska & Łada-Maśko, 2021) are also important. A study by Endendijk (2022) conducted in the Netherlands showed that subtle gender-based expressions by parents based on the infant's sex exist as early as birth announcement cards. Children begin to express gender-typical behaviour in early childhood. For example, Boe and Woods (2017) observed 12.5-month-old babies with gender-typical toy preferences. Areas of child development that affect gender roles include vocalisation, socialisation, play, toys, dress, and décor (Morawska, 2020), with all of them showing children what is "appropriate" for boys and for girls. Gender-specific toys seem to prepare girls for their gender roles in adulthood, by encouraging them to be domestic, take care of the household and children, and have hobbies, while toys for boys are focused on professions, expertise, heroism, aggressivity, action, competition, and dominance (Blakemore & Centers, 2005; Reich et al., 2018). Another gender-typed phenomenon is superhero exposure, which is not only associated with heroism and action but has also, in the case of boys, been proven to be associated with weaker egalitarian attitudes toward women (Coyne et al., 2022). On the other hand, playing the princess in the case of girls teaches them to be nice and passive (Golden & Jacoby, 2018).

Gender socialising is not only a matter of childhood, however, but intensifies during adolescence (Basu et al., 2017; Hill & Lynch, 1983). During this period, gendered parental communication (e.g. different rules, sanctions, norms and expectations for sons and daughters), as well as stereotypical masculinity and femininity norms (e.g. physical toughness, autonomy, emotional stoicism, and heterosexual prowess in the case of boys, and showing emotions or physical weakness for girls) play an important role in perpetuating gender inequality (Kĺgesten et al., 2016).

A study by Moreau et al. (2021) conducted in culturally different cities in Kinshasa, Shanghai, Cuenca, and Indonesia showed that patterns of gender norms vary based on cultural background. Even in societies with prevailing egalitarian parenting, and where explicit gender-based expectations on children are absent (e.g. "dolls are for girls"), implicit and unconscious gendered parenting practices still exist – through direct messages regarding children's behaviours, skills, and interests, as well as through indirect ones directed at others (Mesman & Groeneveld, 2018).

Looking at adults and public space, Day (2001) compared it to a stage where gender identities are performed – men present themselves as brave and tough and contrast this with women whom they consider fearful and vulnerable, even if they perceive public space as safe. According to the same author, however, women can also play up their gender identities by themselves calling for protection and chivalrous behaviour from men to appear fragile and dependent. On the other hand, according to Sutton and Farrall (2005), men often tend to give socially desirable responses regarding their fear levels instead on expressing their true feelings, pointing to the fact that they may be more afraid than they admit. This is in line with the normative perspective of gender norms and traditional masculinity ideology, according to which men should e.g. avoid femininity, be tough, dominant and have restricted emotionality (Levant et al., 2013), as well as with some other masculinity features such as self-control, competition, aggression and physical strength (Day et al., 2003).

Gender differences are also visible in constrained (precautionary, adaptive) behaviour. Most authors have agreed that precautionary strategies can be either passive, referring to avoidance behaviour or active, involving protective or defensive actions (e.g. Doran & Burgess, 2011; Krulichová & Podaná, 2019; May et al., 2010; Stark & Meschik, 2018). The classification of precautionary strategies across studies is not uniform, however. Looking at avoidance behaviour, general agreement is that avoidance has its spatial (to avoid certain places), spatio-temporal (to avoid certain places at certain times) and temporal (e.g. to avoid going out at night) dimensions (e.g. Ceccato et al., 2021; Van der Burgt, 2015). Other authors consider abstaining from certain events, activities (May et al., 2010) or types of people (Krulichová & Podaná, 2019)

to be avoidance behaviour as well. Moreover, the definition of avoidance behaviour may vary based on the specifics of the research. For example, in a transport environment, avoidance can be manifested in avoiding particular routes, stops, destinations and travel modes (Stark & Meschik, 2010). As shown by Doran and Burgess (2011), the level of avoidance relates to specific types of perceived threats, as well as it differs according to the time of the day, with night-time being related to the highest levels of avoidance.

Looking at protective and defensive actions, these can be defined as "strategies for dealing with the risks you come across" (Van der Burgt, 2015, 182) and are most frequently linked to property and personal crime. Property crime – e.g. protecting one's home from break-in or robbery by installing alarms and other items for security reasons (Ferraro & LaGrange, 1987; Jackson & Gouseti 2012; May et al., 2010), is, however, not a subject of our study (with the exception of robbery committed in public space). On the other hand, regarding personal crime, research to date has shown people using various actions to prevent it and feel safer (e.g. carrying a weapon or repellent, being accompanied by a person or a dog, pretending to have a 'phone call) – for more detailed information see e.g. Stark and Meschik (2018) and Tandogan and Ilhan (2016).

As shown by some authors, however, people use more varied risk management and fear-managing strategies than just avoidant and protective behaviour. For example, Van der Burgt (2015) revealed avoidance, risk-confronting (like defensive) and empowerment strategies to be implemented by older teenagers. There, empowerment strategies are mentioned in relation to resisting representations and feelings of fear and risk and are mostly represented by telling yourself there is no reason to be afraid and claiming public space (insisting on ones right to the city) – for more details of related studies see e.g. Koskela (1997), Panelli et al. (2005), Sandberg and Coe (2020) and Sandberg and Rönnblom (2013).

Research to date has shown that women engage in avoidance behaviour more often compared to men (e.g. Krulichová & Podaná, 2019; May et al., 2010). In terms of defensive behaviour, however, the results are inconclusive. While some authors found men applying defensive behaviour more often than women – especially weapon carrying (Baiden et al., 2021; Kuntsche & Klingemann, 2004), other researchers observed the opposite results (Maruthaveeran & Van den Bosh, 2015; May et al., 2010).

Similar findings were revealed when considering transit environments, where females tend to take precautionary behaviour significantly more often than males (Ceccato et al., 2021). Even so, women cannot be considered a homogenous group in this regard. For example, as found by Stark and Meschik (2018), women who have endured frightening experiences tend to avoid certain destinations, routes, and travel modes more than others. Moreover, d'Arbois de Jubainville and Vanier (2017) found that not only those women who have already experienced victimisation, but also older and highly educated ones avoid certain times of the day, as well as transportation lines and places.

3. Methods

3.1 Study area

This research was conducted in the very small post-socialist town of Fiľakovo located in a southern periphery of Slovakia (Central Europe), which is typical for its economic deprivation and related migration from the region (Fig. 1). As of December 31, 2022, the number of inhabitants was 9,770, and

Fig. 1: Location map of the study area (Fiľakovo) in central Europe
Source: authors' elaboration

since 2011 the population decreased by 9.55% (Statistical Office of the Slovak Republic, 2023). Since the town is not served by intra-urban public transport, there is a need for adolescents to choose other transport modes, such as travelling by car with adults or walking. Especially walking through the town creates a prerequisite for one's own direct experience with public space, along with potential threats that could be found there. The study area was chosen with the assumption that adolescents that are more dependent on walking have more personal experience with public space to take part in this kind of research compared to those living in other urban areas. The study area was set within the administrative boundaries of the municipality, with town districts that are not part of the compact built-up area of the town being excluded from the research (Fig. 2), since their morphological structure is like that of rural settlements, as well as these districts are not reachable by foot, and therefore not relevant for this research. The study area is typical for its various morphological and functional structure and was built gradually in different time periods. Looking at population structure, Fiľakovo is typical for its ethnic and racial heterogeneity. The share of inhabitants with Slovak nationality in Fiľakovo is 28.02%, with Hungarians comprising the largest minority (Juhascíková et al., 2012).

Additionally, a non-negligible part of the population (31–40%) belongs to marginalised Roma communities (MVSR, 2019). Most studies from the United States and Europe have shown that ethnicity, race, and diversity are strongly associated with fear of crime (e.g. Eitle & Taylor, 2008; Hooghe & de Vroome, 2016; Quillian & Pager, 2001). Hipp (2013), on the other hand, found very little evidence of this.

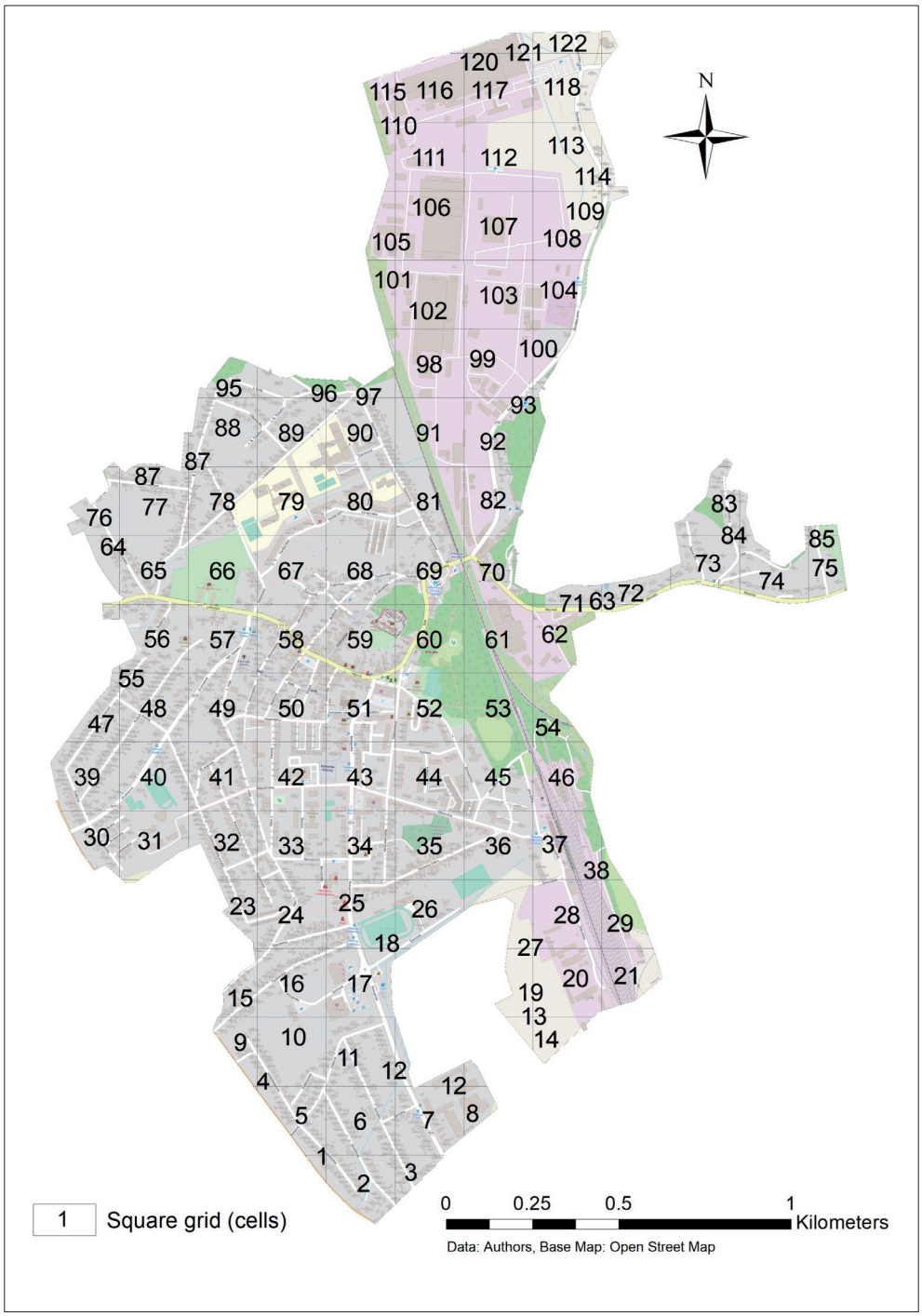

Fig. 2: Map of the study area divided by a square grid with numerically assigned cells
Source: authors' elaboration based on Open Street Map

3.2 Participants and procedure

Unsafety perception of children and adolescents in public space has often been studied using questionnaires with the possibility to obtain a large sample of participants, yet with limited information on respondents' behaviour – most often with the aim of quantifying (e.g. Bromley & Stacey, 2012; Christian et al., 2016b; Johansson et al., 2009; Krulichová & Podaná, 2019). On the other hand, focus groups and in-depth interviews (e.g. Reese et al., 2001; Molnar et al., 2005) enable a deeper explanation of individuals' perceptions, with only a limited number of participants. When adequately designed, mapping techniques, on the other hand, allow us to maintain a sufficiently large research sample for quantitative analysis, while providing us with the possibility to partially understand the context of individuals' unsafety perceptions (e.g. McCray & Mora, 2011; Rišová & Sládeková Madajová, 2020).

This study was based on emotional mapping, which has proven to be a suitable tool for examining unsafety perception in public space (see e.g. Jakobi & Pődör, 2020; McCray & Mora, 2011; Pánek et al., 2019; Rišová & Sládeková Madajová, 2020). Additionally, mapping activity has also been shown to be an effective tool for examining young adolescents' feelings towards different places in an urban environment (Van Der Burgt, 2008). The data collection took place in one of the primary schools in Fiľakovo. The final sample consisted of 151 pupils between the ages of 10 to 16 (46.36% girls), and was divided into categories according to gender, age, and residential location (Tab. 1). This age group was chosen for several reasons. First, there has been a decline in the number of children who walk to school (Gallimore et al., 2011). Safety perception is one of the key predictors in this regard, particularly in the case of girls (Hatamzadeh et al., 2017; Soltani & Zamiri, 2011), in addition to the fact that individuals tend to avoid places they perceive to be threatening (Madge, 1997; Ratnayake, 2017). Second, as 10- to 16-year-olds do not have driving licences, it is assumed that they use public spaces sufficiently frequently to be able to evaluate them appropriately. Third, it was important to involve young people in this study because they are one of the most overlooked categories of public space users. Finally, as pointed by Bromley and Stacey (2012), adolescents belonging to this age group have usually gained the independence to move around their homes alone.

The mapping activity was performed following Rišová and Sládeková Madajová (2020) and Rišová (2021). The activity was performed in 10 classes, while its duration was 45 minutes, i.e. of one class lesson each. The participants were given a map of the town divided by square grids of numerically assigned cells measuring 200 × 200 metres. The total number of cells was 123. Open Street Map was set as a base map. The grid range was limited to the compact built-up area of the town. The size of the map as well as the quality of the base map were chosen so that the map was as readable as possible even for the youngest pupils involved, e.g. the map was large enough so the participants could read names of the streets. Participants in each class formed two groups, each of them working with one large map of the town. Each participant was given a printed pre-prepared reply form that asked about their safety perceptions and precautionary behaviour. Participants were asked to fill the forms without the mutual influence of their classmates, but we are aware that this cannot be completely eliminated, since they are used to communicate with each other. Both the teacher and the researcher were present during the entire activity to help the pupils if needed.

Category		Number	%
Gender	Girls	70	46.36
	Boys	81	53.64
Age	Younger (10–12-year-olds; Mean = 11.45)	71	47.02
	Older (13–16-year-olds; Mean = 14.03)	79	52.32
	Not specified	1	0.66
Residence	Local	94	62.25
	Commuter	57	37.75

Tab. 1: Basic characteristics of the sample
Note: Commuters are participants living outside Fiľakovo town, but commuting to school daily
Source: authors' survey

The form consisted of two parts, with the first of them focusing on basic personal characteristics such as age and gender, while the second part of the form consisted of questions regarding unsafety perception. Each question was explained to them before they answered. They were then asked to find basic landmarks (e.g. their school) to ensure that they were able to read the map properly. To avoid any General Data Protection Regulation (GDPR) violations, the form was anonymised; it contained no information that might have led to the identification of an individual.

3.3 Data and calculations

To examine the unsafety perceptions, the participants were asked to respond to the following statements: (1) in daylight, I do not feel safe in these cells; (2) after dark, I do not feel safe in these cells. In each case, the maximum number of markable cells was 5, to ensure that participants mentioned only places that are the most important for them.

Differences in the number of marked cells were statistically tested using T-tests, with an assumption that more fearful individuals mark a greater number of cells. Pupils were also asked to give a reason for their answers for each marked cell. The reasons were considered to be perceived threats. Following Rišová and Sládeková Madajová (2020), the threats were clustered into categories. Some of the participants described reasons for marking cells extensively, and therefore it was possible to classify them into a greater number of threat categories. The relationship between the gender and threat category variables was tested using Pearson's Chi-squared test of independence, separately for daylight and after dark.

To obtain information on risk management behaviour, participants were asked to state what type (if any) risk management strategy they use in places perceived as unsafe in daylight and after dark. In the same manner as the perceived threats, the risk management strategies were thematically clustered into categories. Several participants mentioned more than one strategy – in that case, each was categorised separately. In addition, three types of precautionary behaviour were identified: (1) avoidance behaviour (avoiding certain places or people; not going out at all); (2) dependence (reliance) on someone else's help or as a companion when moving through public space; and (3) self-reliance (e.g. self-defence, to move quickly, ignoring problematic people) when moving through public space. Using Pearson's Chi-squared test of independence, these questions were answered:

- Is there a statistically significant dependence between the variables "gender" and "precautionary behaviour"?
- Is there a statistically significant dependence between gender and choosing avoidance among other types of precautionary behaviour?
- Is there a statistically significant dependence between gender and choosing dependent behaviour among other types of precautionary behaviour?
- Is there a statistically significant dependence between gender and choosing self-reliance among other types of precautionary behaviour?

The test was performed for data regarding daylight and after dark separately.

4. Results

4.1 Gender differences in unsafety perception

The results show no gender differences in number of marked cells, which means that neither girls nor boys felt less safe (Tab. 2). Although boys marked more cells compared to girls both in daylight and after dark, the differences were not significant ($p > .05$). On the other hand, the residential location and age of the participants played more important roles in unsafety perception differences. The residents of the town under study reported unsafety perception to a greater extent compared to commuters, with significant differences both during daylight and after dark ($p < .05$). Age differences proved to be significant only in daylight, with older participants feeling more unsafe compared to their younger counterparts ($p < .05$).

4.2 Gender differences in perceived threats

The results of the Chi-squared test showed a statistically significant association between the variables "gender" and "threat category" perceived in daylight ($\chi^2 = 16.94$, degrees of freedom [df] = 9, $p = 0.0497$). As shown in Table 3, in daylight, both genders were most afraid of (1) people in general – with girls stating this reason significantly more than boys ($\chi^2 = 7.14$, df = 1, $p = 0.008$), (2) buildings, streets, and places with negative associations (e.g. cemetery, old abandoned swimming pool, castle) – with no statistically significant gender differences, and (3) general feelings (e.g. "I do not feel well there," "bad feelings") – with no statistically significant gender differences as well.

Looking at the detailed threats description, boys were most scared of the Roma minority (67.90%), while these were mentioned by 50.00% of girls only. The more important threats for girls were individuals described as "unpleasant," "weird," "insane," "dangerous," "bad," "bad company," etc. (62.86% of girls, 56.79% of boys) and people under the influence of drugs, alcohol, or drug dealers (61.43% of girls, 46.91% of boys). Girls were also more scared of perverts and paedophiles (8.57%; 2.47%), there being too many people (8.57%; 2.47%) and fighters (5.71%; 1.23%). Additionally, perceived threats were often based on the participants' personal experience. This was explicitly stated for 24 cells (of which 23 were people-related), for instance, "I found a syringe," "They chased me there," "(…) I fought there several times," "They attacked me there," "They shouted at me and threw stones," "Addicts wanted to give me drugs there," and so on. Boys reported a bad experience more often (18.52%) compared to girls (11.43%).

After dark, the results obtained using Chi-squared test proved that the relationship between the gender and threat category perceived after dark variables was statistically significant ($\chi^2 = 20.99$, df = 10, $p = 0.021$). As shown in Table 4, after dark, the most important threat categories stated by both genders were (1) people-related, (3) buildings, streets, and places with negative associations, and (2) darkness and a lack of lighting. Girls were significantly more scared of people compared to boys ($\chi^2 = 7.32$, df = 1, $p = 0.007$). On the other hand, boys reported feeling significantly more unsafe in buildings, streets, and places with negative associations compared to girls ($\chi^2 = 7.97$, df = 1, $p = 0.005$). For instance, boys noted feeling more unsafe due to the cemetery and ghosts (13.58%; 4.23%). On the other hand, darkness and a lack of lighting was stated by 11.43% girls and 9.88% boys, although, the difference did not prove to be statistically significant. In terms of the detailed threats description, unlike in daylight, people under the influence of drugs, alcohol or drug dealers were the most often mentioned people-related threat by both genders (44.29% in the case of girls, 41.98% in the case of boys). Moreover, girls struggled more with the Roma minority (41.43%) compared to boys (33.33%), which contrasted with daylight values. As in daylight, however, individuals described as "unpleasant," "weird," "insane," "dangerous," "bad," or "bad company," were mentioned more often by girls (34.29%) than by boys (23.46%).

	Gender				Statistics		
	Mean in group		Median in group		Prevailing	p-value	Significance
	Boys	Girls	Boys	Girls			
Day	2.74	2.43	3	2	Boys	0.222	No
Night	1.86	1.86	1	1	Boys	0.980	No
Residential location							
	Mean in group		Median in group		Prevailing	p-value	Significance
	Locals	Commuters	Locals	Commuters			
Day	2.86	2.16	3	2	Locals	0.008	Yes
Night	2.17	1.35	2	1	Locals	0.004	Yes
Age							
	Mean in group		Median in group		Prevailing	p-value	Significance
	Younger	Older	Younger	Older			
Day	2.24	2.91	2	3	Older	0.009	Yes
Night	1.75	1.96	1	2	Older	0.448	No

Tab. 2: Differences in unsafety perception according to gender, residential location, and age
Source: authors' survey

Threat categories	Frequency girls	Per 100 girls (%)	Frequency boys	Per 100 boys (%)
People-related threats	142	202.86	158	195.06
Buildings, streets, places with negative associations	13	18.57	28	34.57
General feelings description	7	10.00	7	8.64
Other ("it's high," "I may fall," coronavirus, etc.)	2	2.86	9	11.11
Lack of people, empty, abandoned	2	2.86	0	0
Traffic	1	1.43	2	2.47
School	1	1.43	6	7.41
Dogs	1	1.43	4	4.94
"I don't know it there," "it's far away"	1	1.43	4	4.94
Dilapidated buildings, broken objects, syringes	0	0	2	2.47

Tab. 3: Perceived threat categories in daylight
Source: authors' survey

Threat categories	Frequency girls	Per 100 girls (%)	Frequency boys	Per 100 boys (%)
People-related threats	100	142.86	93	114.81
Buildings, streets, places with negative associations	9	12.86	29	35.80
Dark and lack of lighting	8	11.43	8	9.88
General feelings description	4	5.71	3	3.70
Lack of people, empty, abandoned	3	4.29	2	2.47
"I don't know it there"	2	2.86	2	2.47
Wild animals	1	1.43	0	0.00
School	1	1.43	2	2.47
Dogs	0	0.00	6	7.41
Traffic	0	0.00	2	2.47
Other	0	0.00	2	2.47

Tab. 4: Perceived threat categories after dark
Source: authors' survey

4.3 Gender differences in precautionary behaviour

In places perceived as unsafe, the participants implemented a wide range of risk management strategies, which can be further categorised as avoidant, dependent, and self-reliant behaviours. In daylight, 84.29% of girls and 82.72% of boys mentioned at least one risk management strategy in the form. In the daytime, avoidance behaviour included avoiding certain people or places, but no participant stated to avoid going out in a particular time period. Dependent behaviour involved walking where people are or having a companion (friends or parents), calling someone (friends, parents, or police), and screaming (for help). On the other hand, self-reliance was represented by changing the road after encountering a threat (e.g. "I go away," "I take a detour," "I turn around and go in another direction," or "I hurry away"), self-defence (e.g. "I will find a weapon and use it"; "I will beat them," or "I will defend myself"), not communicating with problematic people or strangers or ignoring them (e.g. "I ignore them" "I leave it as it is," "I don't talk to strangers," "I don't communicate," "I don't listen to strangers," "I don't make eye contact", or "I pretend not to hear"), carrying a weapon (a knife, a pen), to move quickly (e.g. "I run," "I move quickly," "I quicken my step"), feigning a phone call, pretending to not be afraid, being careful, and hiding after seeing a threat (Tab. 5). In the daytime, the results of the Chi-squared test showed a statistically significant association between the variables "gender" and "precautionary behaviour" ($\chi^2 = 11.91$, df = 2, p = 0.003). Girls implemented dependence among other types of behaviour significantly more often compared to boys ($\chi^2 = 10.29$, df = 1, p = 0.001). On the other hand, no significant gender differences were found when looking at avoidance and self-reliance.

After dark, at least one risk management strategy was reported by 74.29% of girls and 71.60% of boys. The avoidance behaviour after dark referred not only to avoiding certain people or places, but also not going out at all (e.g. "I do not go out after dark at all"). As in the daylight, dependent behaviour included calling someone, screaming for help and walking where people are or having a companion (friends or parents). Self-reliance concerned being close to lighting ("I am at lights," or "I always carry something that lights up"), carrying a weapon (keys, a gun), self-defence (e.g. kickboxing, martial arts, "I will defend myself"), changing the route after encountering a threat (e.g. "I will go away," "I will go home," or "I will take a detour"), moving quickly (e.g. "I run," "I move quickly," "I am in a hurry," or "I ride a bike to be faster"), not communicating with problematic people and strangers (e.g. "I ignore them," " I don't talk to them," "I don't communicate," "I don't listen to them," or "I don't make strong eye contact"), being careful, hiding after seeing a threat, pretending to not be afraid and feigning a phone call (Tab. 6). After dark, the relationship between the variables "gender" and "precautionary behaviour" proved to be statistically significant ($\chi^2 = 7.07$, df = 2, p = 0.029), with girls choosing dependence among other types of precautionary behaviour significantly more often than boys ($\chi^2 = 4.88$, df = 1, p = 0.027). Avoidance and self-reliance behaviour was gender neutral.

4. Discussion and conclusions

This study used data on the unsafety perceptions, perceived threats, and precautionary behaviour reported by adolescents to question some of the gender stereotypes regarding fear in urban areas. Several important results emerged.

First, regardless of the daylight, girls did not feel significantly less safe compared to boys, which contrasts with the prevailing body of literature pertaining to adults (Johansson & Haandrikman, 2021; León et al., 2022; Mak & Jim, 2018; Soto et al., 2022), as well as adolescents (Johansson et al., 2009; McCray & Mora, 2011; Rišová & Sládeková Madajová, 2020). This can be explained by the underrepresentation of those threats that have been generally considered to cause the gender differences in unsafety perceptions. In particular, the fear of sexually motivated perpetrators which, according to the "shadow of sexual assault" theory, is the primary cause of the gender-fear

Risk management strategies	Frequency girls	Per 100 girls (%)	Frequency boys	Per 100 boys (%)
Avoiding certain people or places	14	20.00	20	24.69
Calling someone	6	8.57	1	1.23
Changing the road after encountering a threat	2	2.86	9	11.11
Self-defence	0	0.00	8	9.88
Being careful	2	2.86	3	3.70
Not communicating with problematic people or strangers	13	18.57	15	18.52
To hide	0	0.00	2	2.47
Pretending to have a phone call	2	2.86	0	0.00
Pretending to not be afraid	2	2.86	1	1.23
Screaming (for help)	2	2.86	1	1.23
To carry a weapon	1	1.43	2	2.47
To have a companion/to walk where people are	18	25.71	5	6.17
To run/move quickly	16	22.86	3	3.70

Tab. 5: Risk management strategies implemented in daylight by the participants
Source: authors' survey

Risk management strategies	Frequency girls	Per 100 girls (%)	Frequency boys	Per 100 boys (%)	Prevailing
Avoiding certain people or places	13	18.57	10	12.35	Girls
Calling someone	2	2.86	1	1.23	Girls
Changing the route after encountering a threat	4	5.71	6	7.41	Boys
"I am at lights," "I always carry something that lights up"	2	2.86	1	1.23	Girls
Being careful	2	2.86	2	2.47	Girls
Self-defence	0	0.00	3	3.70	Boys
"I do not go out after dark at all"	7	10.00	15	18.52	Boys
Not communicating with problematic people or strangers	9	12.86	7	8.64	Girls
To hide	1	1.43	0	0.00	Girls
Pretending to have a phone call	1	1.43	0	0.00	Girls
Pretending to not be afraid	2	2.86	0	0.00	Girls
Screaming for help	1	1.43	0	0.00	Girls
To carry a weapon	1	1.43	2	2.47	Boys
To have a companion/ to walk where people are	18	25.71	5	6.17	Girls
To run/move quickly	10	14.29	6	7.41	Girls

Tab. 6: Risk management strategies after dark reported by the participants
Source: authors' survey

paradox (Ferraro, 1996), was rarely explicitly mentioned by the participants. In addition, when considering fear of the dark, which has been proven to be a more serious concern in the case of adult women compared to men (Fredrikson et al., 1996), as well as in case of adolescent girls compared to boys (Johansson et al., 2009; Rišová & Sládeková Madajová, 2020), no significant gender differences were found in our study.

Second, in both daylight and after dark, the relationship between the variables "gender" and "threat category" proved to be statistically significant. In daylight, the subject of gender differences was the people-related threat perception, with girls perceiving such a threat category significantly more often compared to boys. After dark, significant gender differences were found in people-related threats (with girls mentioning them more often), as well as in buildings, streets, and places with negative associations (mentioned more by boys). In line with Bromley and Stacey (2012) and Rišová and Sládeková Madajová (2020), regardless of the time of the day, girls stated that they more often struggle with people under the influence of drugs, alcohol, or drug dealers. In addition, girls more frequently observed individuals described as "unpleasant," "weird," "insane," "dangerous," "bad," "bad company," etc., as a threat. This relates to findings by Bastomski and Smith (2017) reporting women being more sensitive to public incivility compared to men, especially when considering tailgating, pushing in crowded spaces, and yelling or cursing. Interestingly, in Fiľakovo, traffic was hardly mentioned as a threat. This can be explained by the size of the town, together with its spatial peripherality and related low traffic volume. Nevertheless, findings from studies conducted elsewhere are inconclusive, as some of them show traffic to be a gender-neutral threat (Johansson et al., 2010, 2012), while others claim that girls struggle more with it (Oestreich et al., 2021).

In terms of precautionary behaviour, regardless of the time of the day, in places perceived as more unsafe, girls performed dependence among other types of behaviours significantly more often than boys. For example, girls tend to call someone to feel safe to a greater extent compared to boys. In the literature, using a mobile phone has been shown to be a common risk management strategy in public space (e.g. Ceccato et al., 2021; Stark & Meschik, 2018). In a study by Nasar et al. (2007), female university students felt safer with mobile phones than males. After a crime, however, males called for help more often than girls. On the other hand, in the same analysis, females more often than males reported feeling encouraged when carry a mobile phone to walk somewhere they would not normally go.

Other dependence strategies including having a companion, whether friends or parents, which girls implemented more often. This is in line with literature examining only women, showing that they prefer to have social support while using public space due to safety reasons (Krenichyn, 2004). On the other hand, a study by Foster et al. (2004) examining both genders reported no significant gender differences in preferring to have company during a walk among adults. Looking at actual walking, however, an analysis by Clifton and Livi (2005) found men walking alone significantly more often than their women counterparts, while women walked with family or friends significantly more often compared to men. In a study by Molnar et al. (2005), adolescent girls found using escorts as an effective strategy to prevent violence and stay safe. According to Clifton and Livi (2005), dog walking is also positively associated with feeling of safety (Cutt et al., 2007; Cutt et al., 2008), with the effect being stronger in the case of women (Christian et al., 2016a). In a study by Christian et al. (2016b), being accompanied by an older sibling or a family dog was positively associated with the independent mobility of children and adolescents. In our research, however, no participant mentioned walking a dog as a risk management strategy.

Interestingly, no gender differences were found regarding avoidance and self-reliance. The findings concerning avoidance behaviour contrasts with the prevailing body of literature showing women being more avoidant (Krulichová & Podaná, 2019; May et al., 2010). In studies examining adolescents, avoiding dangerous people, staying home, and remaining calm when confronted, were among the main violence-preventing strategies among girls (Molnar et al., 2005), while boys in a study by Reese et al. (2001) did not consider it beneficial to walk away from a fight, as it could ultimately lead to bullying.

In Slovakia, gender differences in unsafety perception of adolescents (without considering risk-management strategies) were examined only in Banská Bystrica city, which, however, is of different population size, not peripheral, and is racially and ethnically homogenous when compared to Fiľakovo (Rišová & Sládeková Madajová, 2020). On the other hand, spatio-temporal patterns of adolescents' unsafety perception in a small peripheral Slovak town of Želiezovce was examined in the study by Lorenc & Rišová (2022), but without considering gender differences. In contrast with both the studies mentioned above, in our research, the Roma minority was mentioned with much more negative associations by the participants. In addition, in Fiľakovo, adolescents mentioned their own experience with crime (physical attacks, drug sales, etc.), which was not the case in other two studies. On the other hand, in Fiľakovo, only a few participants did mention fear of cemeteries, scary places and mysteries in general, while in Rišová and Sládeková Madajová (2020) and Lorenc and Rišová (2022), fear of places with negative associations and statements like "it haunts there" were among the most often mentioned threats in public space.

Our results are subject to several limitations. First, we do not know to what extent the participants' decisions regarding avoidant behaviour were the subject of their own choice, as in this age group, the influence of parents can still play an important role in risk management behaviour, as well as in overall decision-making processes. Another limitation pertains to the research design, as the data were obtained using pre-prepared forms, so the information on motivations and reasons for the behaviour are not extensive. Insufficient map literacy of children and adolescents can affect results as well, but to mitigate such an effect, participants in this study were provided with continuous assistance from both the teacher and the researcher, and the map was large enough so the participants could read names of the streets and the map was adapted to the research accordingly as well. Additionally, response bias (such as e.g. socially desirable responding) were not measured and controlled in this study. Also, the results can be biased by the specifics of the research area, as small towns with a high degree of peripherality and economic deprivation may create different types of threats compared to other types of settlements. Therefore, the results should be interpreted accordingly. Finally, it is important to be careful when comparing our results with studies using different methodologies. The specifics of research on unsafety perception are related to various methods of data collection (questionnaires, interviews, mapping activity, etc.), as well as different approaches to data analysis (qualitative/quantitative/combination), which can also affect the nature of the results obtained. Each of the mentioned methods can be limited in terms of results accuracy, missing or insufficient information about the context, and explanation.

We showed that even in the case of adolescents, the idea that girls perceive more threats than boys is rather simplistic and should not be considered universally valid. The extent to which girls and boys perceive danger in public space depends on the type of threat. This study also confirmed that the perception of women as more avoidant is a certain form of gender stereotype and should not be considered a generally valid paradigm. Regardless of gender, however, the impossibility of free independent movement around the city is limiting and directly affects the quality of public space use, as well as endangering social justice. Therefore, in the future, researchers and municipalities should consider how to help their residents and visitors to feel safer. Municipalities can collect detailed behavioural data on unsafety perception and risk-management strategies to gain knowledge on possibilities to enhance public space use, to protect their inhabitants if possible, and to promote equality in public space. This study showed a possibility for such data collection directly during a class-lesson, which has an advantage especially in terms of time efficiency (the possibility of collecting large amounts of data in a short time), while enriching school teaching by exercises focused on of spatial orientation. Such techniques can be, however, used for other groups as well, for example the elderly can participate in the research in the pensioners' club (a common facility in Slovak towns), while other groups can practice mapping techniques in addition to focus groups methods.

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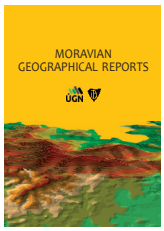

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Spatial planning as a tool of flood risk management in rural landscapes? Position, limitations, and other findings: The case of Myjava Region (Slovakia)

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Abstract

In the context of flood risk management, the application of spatial planning is challenging. This article specifies the position of spatial planning in the context of flood risk management in Slovakia. Through a case study, it assesses the potential of municipal spatial plans to reduce flood risk in rural landscapes. The analysis of municipal spatial plans includes the following aspects: the legislative framework, the actionability of spatial plans and the competences of municipalities. The results showed that in terms of key aspects of flood risk management in the rural landscape, i.e. reducing flood risk through the application of eco-stabilisation measures and reducing the negative consequences of floods through the functional and spatial arrangement of the rural landscape, spatial plans have the status of a formal document. There are several reasons for this. The first one is centralised governance of flood risk. The second reason is the flood risk policy where protection by the technical infrastructure is dominant. The third reason is inconsistent use of municipal powers to reduce flood risk based on a spatial plan. The expectation that the municipalities' spatial plans could contribute to effective flood risk management in the rural landscape thus remains a challenge.

Key words: *Spatial planning, flood risk, rural landscape, municipality, environment and ecological stability, Slovakia*

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1. Introduction

The increased incidence of floods in recent decades and their negative consequences indicate that tackling floods solely based on flood protection through technical infrastructure is no longer sufficient (Di Baldassarre, 2018). Therefore, the flood paradigm is changing and the strategy for flood protection is gradually moving towards integrated flood risk management focused on the reduction of potential flood risk through the application of a diversified set of strategies and measures. These aim not only to reduce flood hazard but also to reduce the social vulnerability and increase the resilience of society to floods (APFM, 2004; ISDR/UN, 2007; Sapoutzaki, 2012; Hegger et al., 2016; Priest et al., 2016; McEwena et al., 2018). According to Ran and Nedovic-Budic (2016), the implementation of such an integrated approach in practical activities requires the harmonisation of territorial units, the interconnection of public policies and cooperation between actors.

The regulation of economic activity and settlement in flood-prone areas is generally considered to be one of the key strategies for reducing flood risk potential. The conditions for the location and spatial arrangement of buildings, as well as the regulations of the functional use of the land are set out in spatial planning. According to Neuvel and Van der Knaap (2010) and Dawson et al. (2011), the spatial plan can therefore be considered one of the key non-structural tools of flood risk management. Spatial plans can be developed at the national, regional, or local levels. There is general agreement, however, that community-level spatial planning is crucial in terms of effective flood risk reduction (Begg et al., 2015). Spatial plans at the local level allow the combination of 'technical analysis with community participation to make wise choices among alternative strategies of land use changes' (Burby et al., 2000).

Although spatial planning is generally appreciated for flood risk management, there are several obstacles to its practical implementation. According to Ran and Nedovic-Budic (2017), important obstacles that prevent spatial planning from becoming an effective tool for flood risk management include, for example, a lack of communication and coordinated action between spatial planning and flood risk management authorities. In addition, planners and flood risk managers tend to have different views of the role that spatial planning has in flood risk management. In this context, Burby et al. (2000) emphasise that spatial plans will have little effect if 'they do not result in a program of action that leads to a more hazard-resilient community'.

Spatial plans are a comprehensive document in which several factors, such as factors of demographic, social, economic, and sustainable development, nature protection or biodiversity of the territory, play an important role in connection with the development of the territory and its spatial arrangement and

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functional use. Therefore, it is not surprising that in spatial plans in many countries, the issue of flood risk 'often takes a back seat' relative to economic development (Begg et al., 2015).

Another important factor influencing the relevance of spatial planning in the context of flood risk management is flood risk governance (Fournier et al., 2018; Kaufmann, 2018; Lifferink et al., 2018; Mees et al., 2018; Matczak et al., 2018; Wiering et al., 2018; Dordi et al., 2020). Flood risk governance is understood as an arrangement of actors, rules, resources, and discourses linked by a common goal of flood risk management (Hegger et al., 2016). In countries such as the Netherlands, where flood risk governance is centralised, i.e. the state is the dominant actor and flood risk reduction is carried out exclusively by technical infrastructure (Kaufmann, 2018), spatial planning is not considered a flood mitigation measure (Neuvel & Van den Brink, 2009). On the other hand, significantly decentralised flood risk governance, together with the application of diversified flood risk management strategies in spatial planning (Böhm et al., 2004), occurs in England (Priest et al., 2016), where flooding issues must be taken into spatial planning (Begg et al., 2015; Green, 2017).

The main objective of this research is to answer the question of whether spatial plans in Slovakia are an effective tool for flood risk management at the local level. Slovakia is a mountainous country and, for the most part, has a rural character; therefore, it is appropriate to analyse the importance of municipal spatial plans in the context of flood risk management in rural landscapes. The region of Myjava in the western part of Slovakia was therefore selected as a case study. In the context of flood risk management in rural landscapes, Rouillard et al. (2015) emphasise the application of measures to increase the retention capacity of the rural landscape by regulating agricultural production and forestry while increasing biodiversity in rural areas. Achieving this is therefore something of a further challenge for municipal planning: the question is whether this challenge will be met. The mere existence of spatial plans at the municipal level does not guarantee that they will function as a real flood risk management tool. By analysing municipal spatial planning within the legislative framework of flood risk management and spatial planning, flood risk governance and the powers and resources of local authorities, we sought to assess whether municipal spatial plans are an effective tool for flood risk management.

2. Case study area: selection of municipalities in a rural landscape

The case study area is represented by the Myjava region in the western part of Slovakia, extending to the Myjava Hills, the Little Carpathians and the White Carpathians. The region includes the cadastral area of 20 municipalities (Fig. 1). The use of municipal spatial plans as a tool for flood risk management in a rural landscape is topical, especially in municipalities with a high flood risk potential. Within the framework of the Preliminary Flood Risk Assessment of the SR (MoE SR, 2011) 27 critical river sections with a potentially significant flood risk located in 15 municipality districts were identified (Fig. 1). Based on a systematic evaluation of the attributes of cadastral areas in terms of their impact on flood risk, Solín and Rusnák (2020) identified eight municipalities with potentially significant flood risk in the Myjava region: Brezová pod Bradlom, Kostolné, Krajné, Myjava, Podbranč, Sobotište, Stará Myjava and Vrbovce (Fig. 2). Of these municipalities Kostolné and Stará Myjava do not have a spatial plan. The remaining six municipalities have a spatial plan, and these are the subject of our analysis. Brezová pod Bradlom (Architektonický atelier BP, 2015) and Myjava (Aurex, s.r.o., 2006; 2020) are obliged to prepare a spatial plan because they have more than 2,000 inhabitants. Municipalities with less than 2,000 inhabitants, namely Krajné (Krušinský, 2014), Podbranč (Mikluš & Halinár, 2019), Sobotište (AŽ Project, s.r.o., 2013) and Vrbovce (Maro SK, s.r.o., 2008; AŽ Project, s.r.o., 2020) have developed spatial plans for various other reasons.

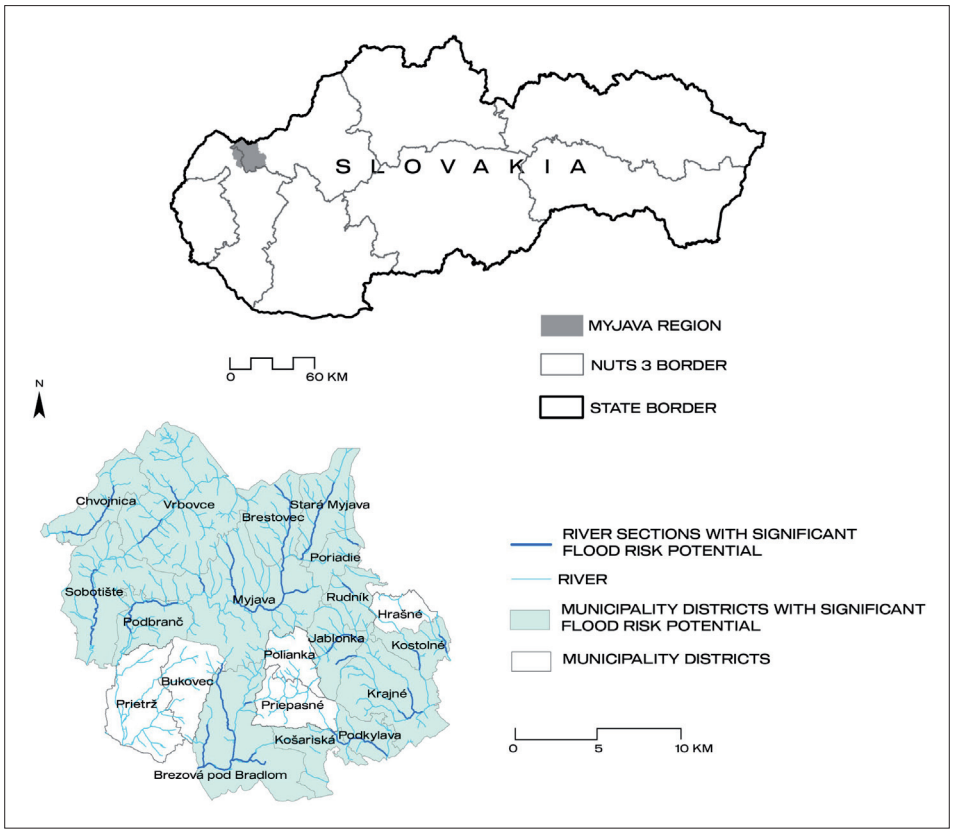

Fig. 1: The Myjava region and river sections with a potentially significant flood risk
Source: authors' elaboration based on MoE SR (2011)

3. Research design

In order to assess whether municipal spatial plans are an effective tool for flood risk management in rural landscapes, we consider it important to answer to the following questions:

i. Whether the flood risk issues are included in municipal spatial plans and, if so, in what context;

ii. Whether application schemes for the implementation of flood protection measures in the cadastral area are developed in the spatial plans; and

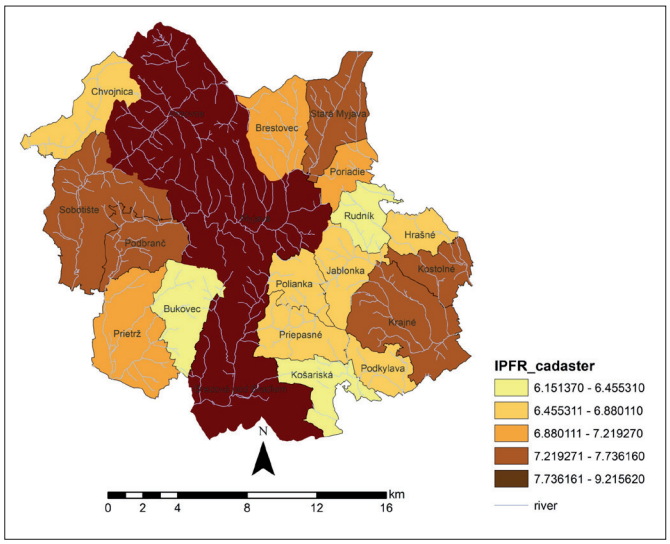

Fig. 2: Spatial differentiation of the municipalities of the Myjava region in terms of flood risk potential index (IPFR)
Source: Solín and Rusnák (2020)

iii. Whether the development of the municipalities is harmonised with the expectations of reducing the flood risk.

To answer these questions, we used a research design including the following aspects: the legislative framework, the action ability of the spatial plan and the competences of the municipalities. A flow chart of the research design is shown in Figure 3.

The starting point of the analytical framework is the analysis of the legislative framework of flood risk and spatial planning. The legislative framework of flood risk management was established by the Flood Protection Act (Act No. 7/2010). The issue of spatial planning is regulated by the Act on Spatial Planning and Building Regulations (Act No. 237/2000).

In assessing the actionability of the municipality's spatial plan in the context of flood risk issues, the analysis focused on:

- How the issue of flood risk is reflected in the objectives of the spatial plans;
- How the required tasks related to the reduction of flood hazard from the superior documents are implemented in the spatial plans of municipalities;
- Whether municipalities formulate their proposals in spatial plans for measures to reduce flood risk at the local level; and
- How landscaping measures, care for the environment and ecological stability are postulated.

In connection with the possible implementation of the flood risk measures, we considered what the real powers and resources (financial, informational) of the municipality were. The overall goal of spatial planning is to ensure sustainable economic and social development of the municipality. In this context it is important to know whether development is in line with the expectations of reducing flood risk. Thus, we assess the spatial and functional

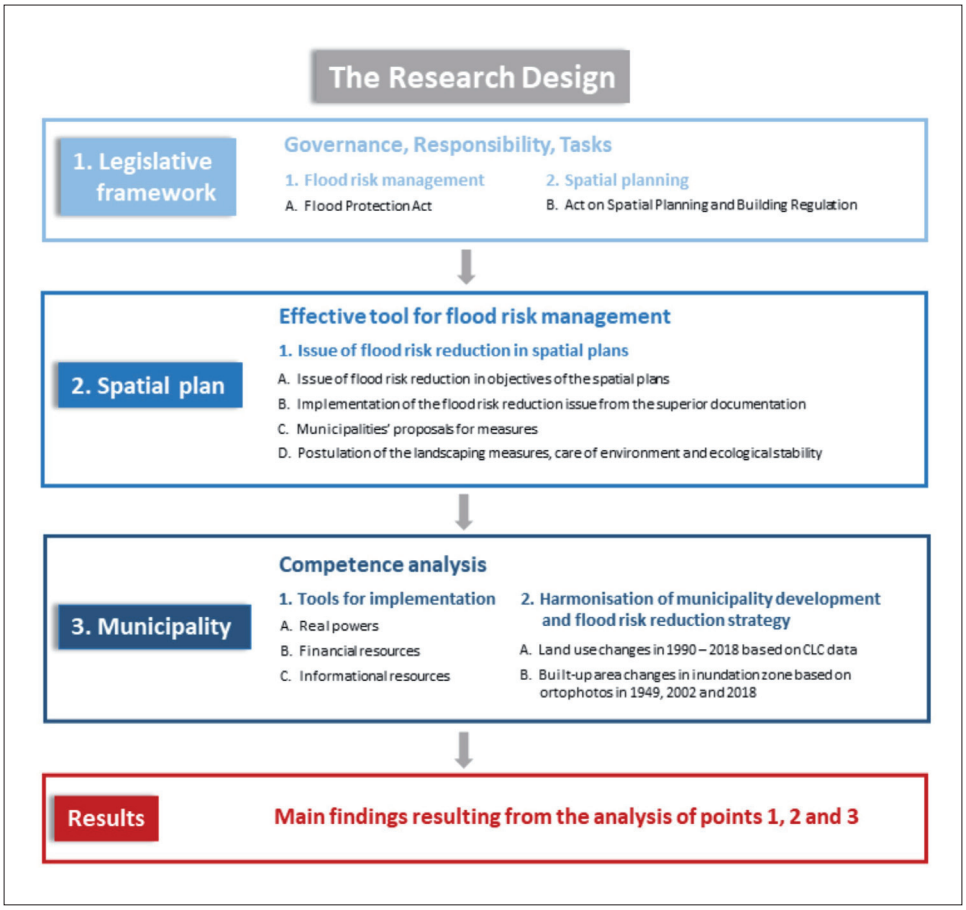

Fig. 3: Flow chart of research design
Source: authors' elaboration

organisation of municipalities in the period 1990–2018. The changes were identified based on CORINE Land Cover (CLC) data from the European Environmental Agency (https://land.copernicus.eu/pan-european/corine-land-cover), which identified the state of land use in 1990, 2000, 2006, 2012 and 2018. The monitoring of changes in cadastral areas was based on an examination of the area of 13 land cover classes of the third hierarchical level of the CORINE Land Cover Nomenclature (Feranec et al., 1996) in the period 1990–2018. Overlaying the land cover allows stable and changed areas to be identified. The CLC data layer, however, has a spatial resolution of 25 ha. Such a distinction greatly limits the mapping of built-up areas, especially in areas where scattered buildings often do not form uniform areas. That is why we decided to map the development of the built-up area in the inundation area of floods with a return period of 100 years on average (MŽP SR, 2015), using black and white aerial photographs from 1949 and orthophotos from 2002 and 2017, with a high spatial resolution of 50cm × 50cm per pixel (years 1949 and 2002), and 20cm × 20cm per pixel (year 2017) (TOPÚ; GKÚ, 2002; GKÚ and NLC, 2017).

4. Results

4.1 Analysis of the legislative framework

4.1.1 Flood legislation

The current legislative framework (Act No. 7/2010) creates a strongly centralised state governance of flood risk. The decisive state authority responsible for the management of flood risk is the Slovak Water Management Enterprise (SVP, state-owned enterprise (hereinafter s-o-p). Other authorities responsible for preventive flood protection, namely state administration authorities (regional district offices, district offices), and self-government authorities (municipalities, higher territorial units/NUTS 3) are legally and professionally lower and their activities in the field of preventive flood protection are tied to cooperation with SVP, s-o-p. The basic documents of the flood protection policy elaborated by SVP, s-o-p. are the Preliminary Flood Risk Assessment (PFRA), Flood Hazard Maps (FHM), Flood Risk Maps (FRM) and Flood Risk Management Plans (FRMP). The concept of flood protection with technical infrastructure is still dominant in FRMP.

According to Act No. 7/2010, the municipalities: i) provide to the SVP, s-o-p, information from spatial planning documentation, which can contribute to the elaboration and updating of PFRA and FRM: ii) coordinate building permits and the regulations of the spatial and functional use of the land in the spatial plan with the measures set out in the FRMP; and iii) ensure the marking of all flood lines shown on the FHM in the spatial plan, taking into account the implementation of prohibited activities across the entire extent of the inundation area determined by the flood lines. Furthermore, the municipalities must respect the protection of the land along the banks of the watercourse to a width of 10 m from the riverbank for the water management of significant streams and 5 m in the case of small watercourses.

Act No. 7/2010 also stipulates that to achieve optimal flood protection, the FRMP as well as the River Basin Management Plan (RSV 2000/60/ES) must be coordinated with other land use planning tools, in particular landscaping projects, spatial planning, and forest plans, with which they will jointly form an integrated landscape management tool.

4.1.2 Spatial planning legislation

The issue of spatial planning is regulated by Act No. 237/2000 according to which spatial planning continuously addresses the spatial arrangement and functional use of the territory, determines its principles, proposes the coordination of activities affecting the environment, ecological stability, cultural and historical values of the territory, territorial development, and landscape creation following with the principles of sustainable development. Spatial plans are developed for different spatial levels. The strategy of territorial development in the state is prepared by the ministry; higher territorial units perform this activity for the territory of regions, and municipalities provide spatial plans of municipalities and act as building permit authorities.

Cities and rural municipalities with more than 2,000 inhabitants are obliged to draw up a spatial plan. Other municipalities are obliged to have a spatial plan when it is necessary to address the concept of their spatial development, carry out large-scale new construction and reconstruction in the municipality or site public works or follow the binding part of the spatial plan of a region, especially to meet international obligations or regarding the location of public transport and technical equipment of the territory of national importance.

The spatial plan of the municipality includes, in particular:

a. Principles and regulations of spatial arrangement and functional use of the territory of the municipality relative to the surrounding territory;
b. Permissible, limited and prohibited functional use of areas;
c. Principles and regulations of care for the environment, the territorial system of ecological stability and landscape creation, including green areas;
d. Principles and regulations of protection and use of natural resources, cultural and historical values and important landscape elements;
e. The boundary between the continuously built-up area and the other territory of the municipality;
f. Principles and regulations of public transport, technical equipment, and civic equipment; and
g. Areas for public works, remediation and for protected parts of the landscape.

The municipality's spatial plan comes into validity after approval by the district office. The condition of approval is the compliance of the municipality's spatial plan with the binding part of the zoning plan of the higher territorial unit. The legislative framework of spatial planning concerning flood risk management shows that through spatial planning (items b, g), the spatial requirements for the implementation of flood protection measures proposed in the PRMP and the regulation of activities in the inundation zone are ensured. The legislative framework of spatial planning, however, also stipulates that municipalities pay attention to the care of the environment and ecological stability of the territory (item c). This is an aspect that can quite significantly affect flood risk in a rural landscape.

4.2 Spatial plan as effective tool for flood risk management

4.2.1 Issue of flood risk reflected in the objectives of the spatial plans

The spatial plans of municipalities set various specific objectives, which relate to ensuring the development of business activities, housing, services, recreation and tourism, preservation of cultural and historical monuments and nature reserves and improving the quality of the environment, among others. Even though the municipalities in question are characterised by a high potential of flood risk and the occurrence of floods in some way limits economic development and causes property, physical and psychological damage, with one exception (municipality Podbranč), no attention is paid to the issue of floods in the specific objectives of the spatial plans.

4.2.2 Required tasks from superior documents

According to the legislative framework, the spatial plans of the municipalities must follow the spatial plan of the higher territorial units (NUTS 3, further as the region). Therefore, they should

consider issues relating to flood protection and environmental policy from the superior documentation. The relevant tasks in the regional authorities' spatial plans (superior documentation) in terms of flood risk reduction are set out in two parts. The first is focused on the arrangement of the land in terms of ecology, nature and landscape protection, as well as the protection of agricultural and forest land. The second deals with the development of the technical infrastructure of water management. They are specified in Table 1. It is important to note that the general tasks of the spatial plans of the regions are formally implemented into the spatial plans of municipalities. They are not elaborated in more details either in terms of specifying their spatial application or listing specific measures or entities responsible for their implementation.

The municipalities' spatial plans must also be harmonised with the FRMP (MoE SR, 2015). Proposed measures are listed in Table 2. Technical flood protection measures for river sections with significant flood risk are precisely specified and their location is stated (see columns 2–3 in Tab. 2). Their implementation is ensured by the creation of a territorial guarantee in the spatial plans. On the other hand, the maintenance measures for watercourses that ensure the flow capacity of the channels are slightly less targetted. In contrast, measures that slow down the outflow of water from a river basin and increase its retention capacity are listed in the FRMP only in a general declarative form. Their provision and implementation are not elaborated in detail in the municipalities' spatial plans either.

Another mandatory regulation resulting from the legislation relates to a 5 m wide area along the banks of a watercourse and the designation of flood lines for low, medium, and high probability floods in the spatial plan. In the case of area along watercourses, it is only generally stated in spatial plans that it must be maintained in such a way that obstructions to runoff make access to the watercourse difficult or impossible or do not encourage sediment deposition. The flood lines for floods with low, medium, and high probability of occurrence, which are shown on FHM must be drawn in the municipal spatial plan at the next update of the approved spatial plan. Apart from Sobotište, other municipalities have already updated their spatial plans between 2014 and 2020, but only Brezová pod Bradlom and Myjava had flood lines drawn in the spatial plan.

4.2.3 Measures for the environment and ecological stability

Measures related to landscaping and environmental care (eco-stabilisation measures) in the spatial plans can be divided into two basic groups, namely measures in the river landscape (watercourses and their riverine zone) and measures in forest and agricultural land. Although eco-stabilisation measures are not explicitly mentioned in the spatial plans in the context of flood risk management, there are measures that could make a significant contribution to reducing flood risk in the rural landscape. A wide range of general principles of watercourse, agricultural and forestry management (Tab. 3) is listed in several variations in the spatial plan of each municipality. In connection with watercourses, the spatial plans of municipalities mention the revitalisation through the maintenance of their channels and riparian vegetation and the preservation of their natural meandering. In the case of agricultural and forest land the application against erosive farming practices on agricultural land and logging in the forest is reported. The general principles of landscaping and environmental care and the application of eco-stabilisation measures in municipal spatial plans in terms of the potential reduction of flood risk in rural landscapes cannot be questioned. The spatial plans of

SECTION	
Land organisation in terms of ecology, nature, and landscape protection and protection of agriculture and forest land	**Water management and flood protection**
• -up areas, especially in public spaces; to develop landscape greenery in implement systems for the proper use of agricultural land and their protection against erosion, weeds, excessive urbanisation, insensitive transport network solutions and all types of waste	• perform maintenance on modified watercourses to maintain the built capacities
• support the solution of erosion problems, which is proposed in the framework of landscaping and within the projects of the local territorial system of ecological stability, through draws, erosion belts and windbreaks	• improve water management conditions on small watercourses and in the river basin by interventions aimed at stabilising conditions in extreme situations, both floods and droughts
• create conditions for stopping the process of reducing biodiversity in the whole territory of the region	• ensure, on the unmodified sections of watercourses, particularly, the protection of urban areas of municipalities and subsequently comprehensively solve run-off conditions following development programmes
• gradually address the issue of building paved and unpaved forest roads so that soil erosion on slopes does not occur	• provide preventive anti-erosion measures, especially on the sloping parts of the Chvojnica and Myjava river basins, pay attention to the observance of correct agrotechnical procedures, planting and maintenance of protective vegetation belts in the vicinity of agricultural areas and the establishment of infiltration areas
• pay attention to the revitalisation of existing streams, complete the accompanying vegetation by planting a belt of domestic tree species and shrubs along the streams and by increasing the share of grasslands in the surrounding microdepressions	• create conditions for timely preparation and implementation of flood control measures
• respect the inundation areas of watercourses in municipalities in the region and define them as inadmissible from the point of view of placement of new buildings	• implement constructions connected with anti-flood measures in the Váh, Nitra and Myjava sub-basins for the protection of urban areas of municipalities following the Flood Protection Programme of the Slovak Republic and for other watercourses in the Váh, Nitra and Myjava sub-basins following the investment development programme of Slovak Water Management Enterprise and water management concept
• supplement the accompanying vegetation by planting strips of native domestic tree species and shrubs along watercourses; build shading strips of greenery along exposed watercourses	• respect the flood lines resulting from flood hazard and flood risk maps, especially in areas where significant flood risk is likely to occur
• increase the level of representation of natural elements in builtbuilt-up areas and the open country	• prevent the formation of stormwater in the area, e.g. designing systems of polders, ditches and retention reservoirs in the country, along with suitable landscaping systems
• minimise the construction of impermeable surfaces in the country	• support the retention of rainwater in the area, in the form of natural retention reservoirs, ponds, building occasional water areas filled only with precipitation or replenishment of green areas
• promote the implementation of adaptation measures to climate change in built-up areas of municipalities through spatial planning tools	• respect the protection zones of watercourses, dikes and inundation areas, where, depending on the circumstances, mainly grass, grass-herbaceous vegetation is applied

Tab. 1: Binding tasks for spatial plans of municipalities related to flood risk resulting from the spatial plans of the regions (Trenčín and Trnava self-governing region)
Source: authors' compilation

MEASURES PROPOSED IN FLOOD RISK MANAGEMENT PLANS			
Measures slowing down the outflow of water in the river basin and increasing its retention capacity	**Measures reducing the maximum flow**	**Measures protecting the area from flooding by water from a watercourse**	**Measures ensuring the flow capacity of the watercourse**
• measures in normally managed forest stands	*Brezová pod Bradlom:* • regulation of the Brezová pod Bradlom water reservoir • area suitable for natural transformation of flood waves in 17.2–18.0 km of Brezovský brook	*Kostolné:* • modification of the riverbed from natural materials to the flow Q100 in km 1.370–1.89 • Dubník water reservoir to build a supporting concrete wall (520 m)	*Brezová pod Bradlom:* • watercourse maintenance (mowing, removal of airborne trees, sediments from the stream and remediation of bank reservoirs)
• comprehensive measures that slow down run-off from the basin, such as adjustments on agricultural land (change of cultivated crops), ploughing along contours, anti-erosion sowing procedures, construction of draws to eliminate soil flushing, construction of infiltration belts	*Podbranč:* • polder Malejov in km 64,434	*Podbranč:* • modification of watercourse in km 64.404 – 64.484 (part of construction ‚Malejov Polder') • modification of the watercourse in km 58.032 –58.555 with the construction of protective dams	*Krajné:* • necessary maintenance of the old modification (Jablonka) • elimination of raids on slopes (Rudník km 2.4–4.0) • maintenance of the Matejovský brook (km 0.900, removal of inadequate culvert)
	Myjava: • polder Cengelka in km 2.10 • polder Padelky on the right-hand tributary of Myjava (Hukov brook) in km 1.20 • polder Smíchov in km 0.605	*Myjava:* • modification of watercourse in km 2.05–2.13 (part of construction Cengelka Polder' • modification of watercourse in km 1.13–1.29 ((part of construction Padelky Polder')	*Kostolné:* • necessary cleaning and removal of sediments (Kostolník km 1.89–2.3)
	Sobotište: • Sobotište water reservoir		

Tab. 2: Summary of proposed measures in FRMP
Source: authors' elaboration

municipalities, however, lack the elaboration of implementation schemes of general ecostabilisation principles with an indication of specific measures and localities within the cadastral area where they are to be implemented and the subject that is to ensure the implementation.

4.2.4 Municipalities' proposals for measures to reduce flood risk at the local level

The legislative framework itself does not explicitly stipulate that the municipalities perceive the spatial plan as a flood risk management tool, which would specify their own proposals for measures to reduce flood risk. Also, the local authorities propose almost no flood risk reduction measures in their spatial plans by their own initiative.

4.3 Competence analysis

4.3.1 Tools for implementation

When considering why municipalities are not motivated to exert more effort and initiative in flood risk management at the local level and develop local application schemes for specific eco-stabilisation measures, three factors come to the fore: a) very weak legislative powers; b) lack of financial resources; and c) insufficient systematic assessment of flood risk with attributes of the cadastral area.

Regarding the implementation of measures on watercourses, according to Act No. 7/2010 the maintenance of watercourses can only be performed by the administrator of watercourses. Municipalities are usually not administrators of watercourses (only about 1% of watercourses are managed by municipalities). So, municipalities cannot perform activities related to the care of watercourses. The mayors of municipalities may submit a request for the maintenance of small watercourses at the time of the flood inspection organised by the district office once every two years. The district office may, by its decision, impose on the watercourse administrator the obligation to eliminate the identified deficiencies, but this process is very inefficient.

The legislative competence of the municipality is limited even in the case of the implementation of ecostabilisation measures on agricultural land. The decisive owners of agricultural land (physical persons) usually lease the land for use to agricultural cooperatives or various agribusinesses. The act on the conservation and use of agricultural land (Act No. 220/2004) stipulates that the owner or tenant is obliged to implement protective agrotechnical measures for erosion protection of agricultural land, such as planting of agricultural and protective greenery; contour agrotechnics; crop rotation with protective effect; mulching intermediate crop combined with no-till technology; and other measures to be determined by the soil service according to the degree of soil erosion. If such protective measures are not applied to eroded soils, the competent authority, which is obliged to request their implementation, is the District Land Office.

Another legislative regulation, which includes the implementation of anti-erosion adjustments on agricultural land, is the Act on Land Arrangements, Land Ownership Arrangements, Land Offices, Land Fund and Land Communities (Act No. 330/1991). According to that law, if it is necessary to restore or improve the functions of ecological stability and the overall character of the agricultural landscape, to reduce agricultural or forestry production due to the declaration of protection zones or to address the consequences of natural disasters, the District Office may order land readjustments. Land improvements include measures to protect the soil from erosion and water erosion (grassing, afforestation, windbreaks, infiltration belts, terraces, dams and canals), measures to protect the environment and create ecological stability of the country's biodiversity (biocorridors, biocentres, interaction elements and accompanying greenery) and water management measures to ensure protection against flash floods, waterlogging and water supply to cover moisture deficit (polder tanks, drainage and irrigation). Landowners may claim some compensation (money or other land) from the state for land subject to adjustment. The agreement on the amount of compensation between the landowner and the state, however, is a critical point of land readjustment.

Municipality	Watercourses	Agricultural And Forest Landscape
Brezová pod Bradlom	• further straightening of streams, strengthening of banks and removal of riparian vegetation in the area and inappropriate regulation of watercourses are not recommended • it is necessary to observe the protection zones of watercourses • it is recommended to extend the already modified riverbeds again	• improvement of physical properties of soils, change of management method and types of crops, ploughing along the contour, creation of catch ditches, planting of protective greenery • division of land, crop rotation, boundaries, draws, seepage ditches • restoration of wetlands, small polders in valleys, small reservoirs, and ponds) • controlled flooding to selected localities in territorial floodplains (based on flood hazard and flood risk maps – not yet processed)
Krajné	• revitalisation of the Jablonka stream in the built-up area of the village • revitalisation and reconstruction of the original riparian vegetation of all streams in the cadastral area • removal of erosive deposits, alluvium, dead wood, various waste, etc. • strengthening of erosion-affected riparian parts of streams	• unequivocally preserve the current spatial organisation of elements of the landscape structure (especially the area with beds, gardens, orchards, permanent grassland, and scattered vegetation in the country) • to preserve the current use of the agricultural part of the country, permanent grassland intensively mown and grazed • prevention of unnatural land formation (uncontrolled overgrowth) • in localities with a slope greater than 12° consider growing broad crops (maize, sunflower) due to high soil flushing, water erosion, etc. • not to plant new areas in the land of the cadastre, to understand the lines of non-forest vegetation in the country as anti-erosion or anti-flood natural elements
Podbranč	• conversion of agricultural crops to permanent grassland on areas of arable land that directly touches the banks of watercourses or is in the meanders of the Morava River	• change of agricultural crops to non-forest woody vegetation in localities where water erosion occurs • network of field roads with vegetation • heavily wetted parts overgrow with moisture-loving vegetation or change to permanent grassland • to improve the technical condition of areas with a built drainage system • increase the share of non-forest woody vegetation along streams and canals, roads and create areas of so-called draws
Sobotište	• completion of vegetation support along water canals and streams	• inappropriate and inadmissible are activities that conflict with the protection and enjoyment of agricultural land, with integrated prevention and control of environmental pollution, with the protection of forest land in spatial planning activities
Vrbovce	• revitalisation of modified sections of the Teplica (Vrbovčianka) stream	• leave non-forest woody vegetation to natural successive development • divide blocks of agricultural land into smaller units by planting landscape greenery • grass important water management areas • maintain the mowing of meadows and orchards, meadows, and pastures in the vicinity of the farmsteads
Myjava	• modification of the Myjava riverbed and adjacent watercourses • retention of original trees of riparian vegetation and their thickening by geographically original species revitalization of watercourses (e.g. Svacenický spring) • Ţriedlovský brook, Brezovský brook, Smíchov polder, Cengelka polder)	• anti-erosion grassing of slopes on which water erosion occurs • exclusion of logging from commercial forests • in the hilly area, leave or create a mosaic-like representation of permanent grassland and arable land • increasing the share of non-forest greenery by planting drawbridges and smaller woods in the open countryside in connection with local landscaping • anti-erosion line elements of greenery – artificially created – elements of tree and shrub vegetation, original tree species planted on agriculturally cultivated soils in the open country, connected to urban greenery

Tab. 3: Landscaping and environmental principles affecting the flood hazard in spatial plans of municipalities
Source: authors' elaboration

4.3.2 Harmonisation of municipalities' development and flood risk reduction strategy

In terms of function, the cadastral territory of the municipality is usually divided into several basic blocks (Tab. 4). For each block, a main function of its use is defined, which can be supplemented by a set of functions of additional functional use as required. For each block, the non-allowable functions of its use are also exhaustively listed.

Development impulses of the municipality, such as population growth, business plans and new investments, among others, exert pressure on the expansion of built-up areas or the change of functional use of the areas as such. The evolution of land cover changes within cadastral areas for the 1990–2018 period, observed based on CLC data, is presented in Figure 4. Then Table 5 summarises the percentage change (increase/decrease) in land cover classes CLC 112 and CLC 121 in individual years. The number of inhabitants in the municipalities has been slowly decreasing over the last 30 years, only Stará Myjava has been growing since 2006 and Podbranč since 2012. The population is related to the housing stock, which is represented by the land

BLOCKS OF TERRITORY
Housing areas – family houses, residential houses
Areas of civic amenities – non-commercial, commercial, school
Multifunctional areas of trade and services
Multifunctional areas of production and services
Industrial production areas
Agricultural production areas
Recreation areas
Sports area
Areas of technical equipment
Areas of orchards and gardens
Meadow areas
Forest areas
Arable land areas
Areas of non-forest vegetation

Tab. 4: Functional blocks of cadastral territory
Source: authors' elaboration

Municipality	Period									
	1990–2000		2000–2006		2006–2012		2012–2018		1990–2018	
	CLC 112	CLC 121	CLC 112	CLC 121	CLC 112	CLC 121	CLC 112	CLC 121	CLC 112	CLC 121
Brezová pod Bradlom	4.80	0.00	9.21	– 2.52	– 0.03	0.00	7.16	43.02	22.61	39.41
Kostolné	0.00	–	– 1.15	–	0.00	–	0.28	–	– 0.87	–
Krajné	0.00	–	– 2.69	–	7.35	–	22.48	–	27.95	–
Myjava	1.92	0.00	– 14.96	– 0.41	12.60	21.18	– 7.61	3.67	– 9.84	25.11
Podbranč	0.00	–	– 41.41	–	24.95	–	– 30.39	–	– 49.04	–
Sobotište	4.76	–	9.64	–	– 2.98	–	– 0.05	–	11.39	–
Stará Myjava	0.00	–	5.78	–	0.30	–	2.78	–	9.05	–
Vrbovce	0.00	0.00	1.31	0.30	– 7.29	0.00	22.72	0.00	15.27	0.30

Tab. 5: Percentage changes in land cover classes CLC112 and CLC121 in the cadastral territory of municipalities in the Myjava region in the years 1990–2018. Source: recalculated EEA

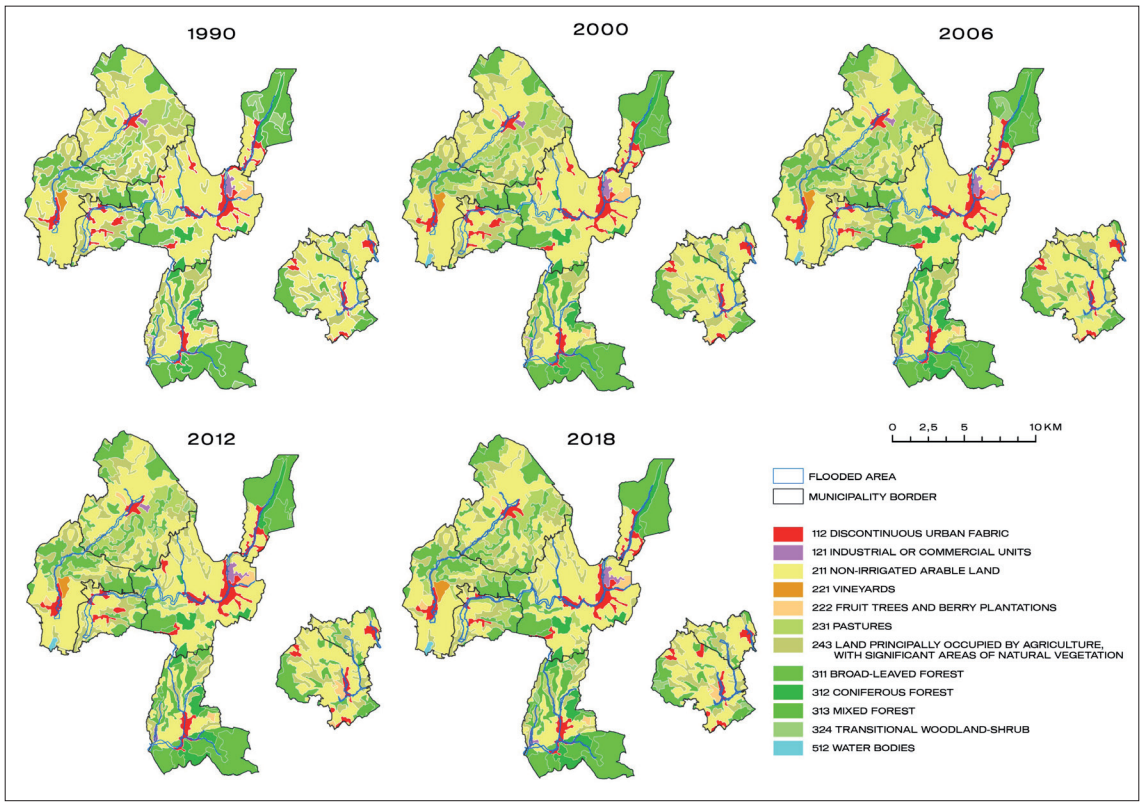

Fig. 4: Changes in landscape cover in the cadastral territory of municipalities in the Myjava region in the years 1990–2018 Source: EEA

cover class CLC 112, discontinuous urban fabric. The analysis of the development of this class shows a slight increase in its area in the cadastral territories in 2018 compared to 1990, except for the municipalities of Myjava, Podbranč and Kostolné, where a decrease in housing construction was observed (Tab. 5). A more significant increase in built-up areas due to the increase in industrial and commercial areas (CLC 121) was observed in 2018 in the municipalities of Brezová pod Bradlom and Myjava.

As mentioned in Section 3, much more accurate information on the development of the built-up area is provided by the analysis of aerial black-and-white images from 1949 and orthophotos from 2002 and 2017 in higher spatial resolution (Fig. 5). A more detailed analysis of the built-up area in the inundation zone delineated by the flood with a return period on average once in 100 years in the municipalities of interest in 1950, 2002 and 2017 is presented in Table 7 and Figure 6. The analysis shows a significant increase in the built-up area in the municipalities' inundation zone from the 1950s to the beginning of the 20th century. In four municipalities (Brezová pod Bradlom, Krajné, Sobotište and Stará Myjava) the built-up area increased by more than 200% in 2002

Population	1991	2000	2006	2012	2018
Brezová pod Bradlom	5,551	5,647	5,431	5,092	4,834
Kostolné	729	684	623	628	586
Krajné	1,878	1,725	1,639	1,587	1,507
Myjava	13,135	13,167	12,729	12,185	11,591
Podbranč	751	670	626	609	614
Sobotište	1,693	1,558	1,508	1,490	1,486
Stará Myjava	781	696	738	744	774
Vrbovce	1,663	1,556	1,536	1,551	1,497

Tab. 6: Population development in municipalities Source: Statistical Office of SR

compared to the year 1950. If we focus on the last 15 years (2002–2017), the increase in the built-up area is slower and in the four municipalities with the highest increase (Stará Myjava, Myjava, Kostolné and Vrbovce) the built-up area in the inundation zone increased by more than 20%. On the contrary, it remained almost the same in the village of Podbranč. When comparing the relative increments, it was shown that among all the monitored municipalities, the most building in the inundation zone was in

Fig. 5: Demonstration of development of the built-up area in higher spatial resolution. Example from Brezová pod Bradlom
Source: TOPÚ, GKÚ, NLC

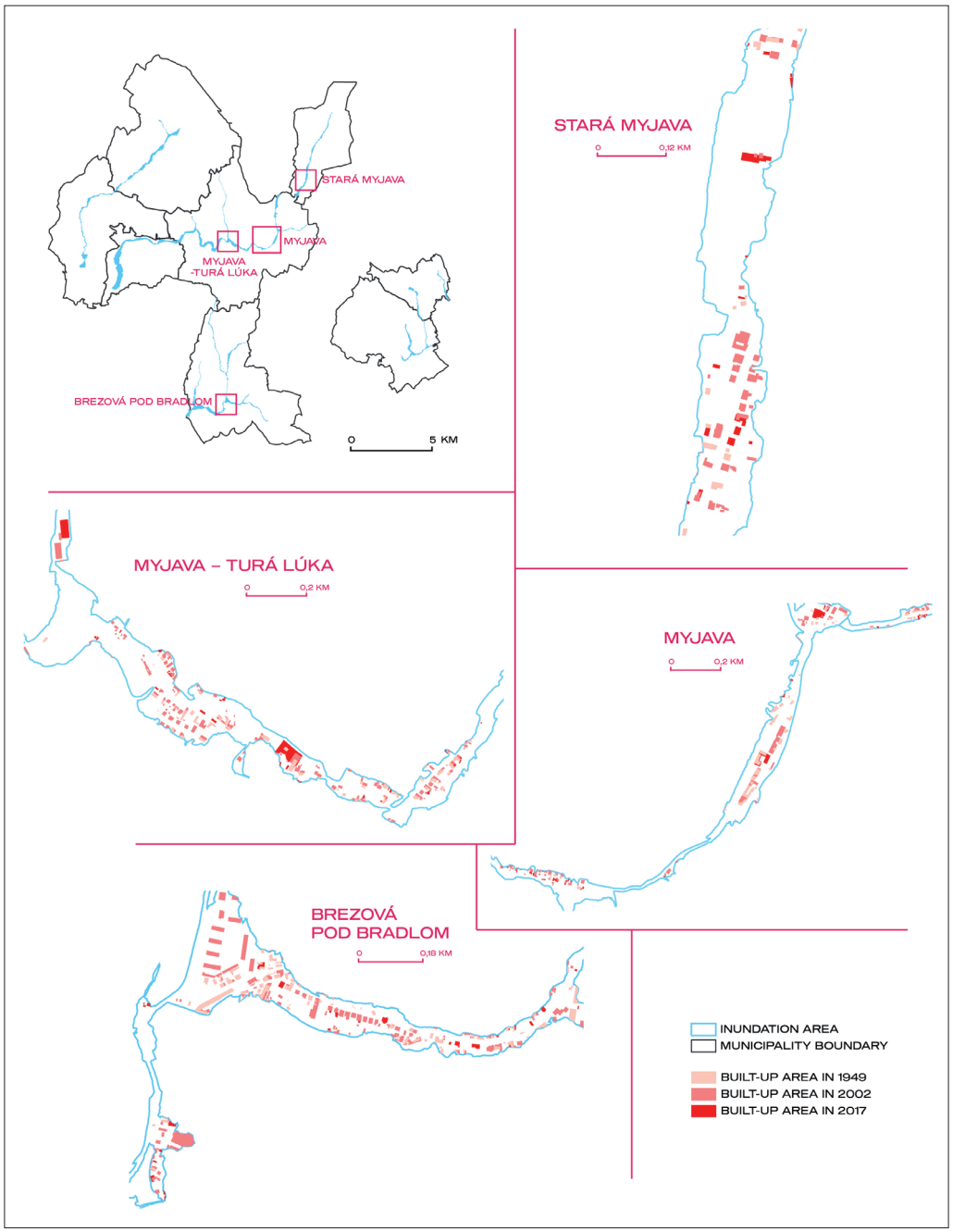

Fig. 6: Increments of built-up area in inundation zone (Q100) of municipalities in different periods
Sources: authors' elaboration based on data from (SVP, š.p., TOPU, GKÚ and NLC)

Municipality	Built –up area (m^2)			Increase* (%)	Relative increase** (%)	Increase* (%)	Relative increase** (%)
	1950	2002	2017	1950–2002	1950–2002	2002–2017	2002–2017
Brezová pod Bradlom	17,239	62,350	66,499	262	43.5	7	17.8
Kostolné	405	685	858	69	0.3	25	0.7
Krajné	8,586	28,307	31,528	230	19.0	11	13.8
Myjava	17,225	33,933	43,263	97	16.1	27	40.0
Podbranč	1,859	2,760	2,776	48	0.9	1	0.1
Sobotište	3,109	10,910	11,626	251	7.5	7	3.1
Stará Myjava	5,077	15,237	19,443	200	9.8	28	18.0
Vrbovce	3,282	6,363	7,877	94	3.0	24	6.5

Tab. 7: Development of built-up areas in the inundation zone of municipalities. Source: authors' calculations
** Percentage increase of built-up area in the municipality's inundation zone for the 1950–2002 and 2002–2017 periods, respectively*
*** Percentage share of the built-up area in the municipality's inundation zone of the total increase in the built-up area in the inundation zone of all municipalities for the 1950–2002 and 2002–2017 periods, respectively*

Myjava, Stará Myjava, Brezová pod Bradlom and Krajné, while occurring almost not at all in Podbranč and Kostolné. This is mainly the construction of family houses or the construction of smaller buildings (garages, garden houses), and to a lesser extent industrial and commercial areas. An example case is the village of Podbranč, in which, despite the increase in population, there has been almost no significant construction in the inundation area in the last almost 70 years.

5. Discussion

The analysis of the spatial plans of the municipalities of the Myjava region showed that the spatial plans have the status of a formal document in terms of the key aspects of flood risk management in the rural country, i.e. increasing the retention capacity of the cadastral area and the maintenance flow capacity of watercourses. There are several reasons why this is the case.

The first one is the governance of flood risk. Although flood risk legislation on flood protection has been progressively clarified, the state's sole responsibility for flood protection has been maintained. The decisive authority responsible for flood risk management is the government organisation SVP, s-o-e, which is responsible for the preparation of all the basic documents for flood protection. Given the centralised way of flood risk governance, it is therefore not surprising that the municipality's ideas on flood risk reduction at the local level are not presented in the municipality's spatial plan, and the spatial plan is not explicitly declared as a flood risk management tool. A spatial plan is considered a tool for creating territorial conditions for the implementation of flood control measures proposed by the flood risk management authority and for an incorporation of general regulation tasks from the superior documentation. The results obtained confirm the conclusions reached by Neuvel and Van den Brink (2009) and Kaufmann (2018) that where flood risk governance is centrally managed, spatial planning is not considered a flood mitigation measure. The other reason is the nature of the flood risk policy. If the concept of flood protection by technical infrastructure is still the dominant food risk management strategy, the measures to increase the infiltration and retention capacity in the rural landscape are considered only complementary and are not financially supported by the State. Their presentation in spatial plans has only a declarative character. Encouraging a more detailed elaboration of eco-stabilisation measures in municipal spatial plans requires decentralisation of flood risk management and a change in flood risk policy, with an emphasis on the application of diversified flood risk management strategies. This aspect of increasing the role of municipal spatial plans in flood risk management is emphasized by Priest et al. (2016), Begg et al. (2015), Green (2017) and Rauter et al. (2020).

The third reason is insufficient flood risk assessment. In terms of diversified flood risk management in the rural landscape, it is not sufficient to identify areas of potentially significant flood risk only based on river reaches that are critical in terms of flooding (*cf*. Adamson, 2018). To proceed with flood risk assessment, systematic processing of data on the attributes of watercourse, riparian zone, physical-geographical attributes and the land use of the cadastral area and their impact on flood hazard and social vulnerability needs improvement. The fact that municipal self-governing authorities do not have systematically processed information on the flood risk of cadastral areas also weakens the elaboration of the implementation schemes of ecostabilisation measures.

The fourth reason is the lack of consistency in the use of municipal powers in the context of the spatial and functional arrangement of the cadastral territory. Alignment of the spatial plans with the development requirements of the municipalities is the main mission of the spatial plan. The municipalities have the power to change the spatial and functional arrangement of the cadastral area, and the power to issue permits for the construction of residential houses, buildings for business purposes, or civic amenities. The development of built-up areas in the floodplain, as well as changes in land cover in the cadastral area in recent decades, indicate that the powers of municipalities in guiding the spatial and functional layout of the area are not consistently being applied to reduce flood risk. Self-governing authorities as well as building offices of municipalities are under pressure to permit the construction of residential houses and buildings for economic activities in areas at risk for floods. This situation is the result of ambiguity associated with the delimitation of the inundation area and giving the decision to not permit building construction. The boundary of the inundation area was not strictly set until the adoption of Act No. 7/2010 and thus raised doubts as to whether buildings were in the inundation area. This explains the increase in built-up areas in the period 1950–2002. Problems with the delimitation of the inundation area, however, arise even after the adoption of Act No. 7/2010. The reason for the disputes is the accuracy of the determination of the flood line. In controversial situations, the building authority usually finds in favour of giving the builder permission to build.

The research is limited to the analysis of spatial plans of municipalities and small towns in the rural landscape. The emphasis is placed on the rural landscape because it includes basins of small watercourses, in which the occurrence of flood risk is influenced by local factors. Eliminating or limiting their impact is the task of flood risk management at the local level. In this context, spatial plans of municipalities (or municipalities as such) should then play an important role.

The added value of the study lies in the fact that the assessment of whether municipal spatial plans represent an effective tool for flood risk management is carried out not only from the point of view of the analysis of the legislative framework of flood risk and spatial planning, but also the way in which the issue of flood risk is incorporated into spatial planning and in the context of the competence analysis of municipalities to realistically carry out flood risk management at the local level.

The intention of the study was not to assess the effectiveness of each spatial plan separately, but to formulate some general conclusions about the real possibilities of municipalities spatial plans to reduce flood hazard (or exposure to flood hazard) at the local level. We believe that information about the current state in this area will become the basis for further development and, above all, the implementation of a more participatory community-level flood management approach.

6. Conclusions

Spatial planning is generally considered to be one of the important tools of integrated flood risk management. In this study, we dealt with the legislative framework of flood protection and spatial planning to specify the position of spatial planning in flood risk management in Slovakia. We further performed a detailed analysis of the spatial plans of municipalities in the Myjava region to obtain an answer to the question of whether municipal spatial plans are an effective tool for flood risk management in rural landscapes.

The current legislative framework creates a strongly centralised state governance of flood risk. The decisive actor of flood protection is the Slovak Water Management Enterprise (SVP, s-o-p). Other actors of flood protection (district offices, municipalities, and higher territorial units) are legally and professionally lower and their activities in the field of preventive flood protection are tied to cooperation with the SVP, s-o-p. The Preliminary Flood Risk Assessment, Flood Hazard Maps, Flood Risk Maps and Flood Risk Management Plans are the basic documents of flood protection in the SR. They were prepared under the responsibility of SVP, s-o-p. Flood protection policy based on technical infrastructure is dominant in flood risk management.

The role of spatial planning in the context of flood risk management is primarily to ensure territorial requirements for the implementation of flood control measures proposed in the FRMP and to fulfil requirements of other superior documentation. The legislative framework, however, also stipulates that municipalities pay attention to the care of the environment and ecological stability of the territory in spatial plans. Although this aspect is not explicitly mentioned in the context of flood risk management, it may quite significantly affect the flood risk in a rural country.

The analysis of the spatial plans of the municipalities showed that, on the one hand, they include the required tasks from the superior documentation, which relate to flood protection but, on the other hand, they are only a formal document from the point of view of key aspects of flood risk management in rural landscapes (i.e. the reduction of flood hazard by increasing the retention capacity of cadastral areas, maintaining the flow capacity of watercourses and reducing negative consequences of floods through functional and spatial arrangement of cadastral areas).

There are several reasons for the formal nature of municipal spatial plans in terms of flood risk management in a rural landscape. The first reason is centralised state governance of flood risk. The local self-government authorities do not have enough authority for the active performance flood risk policy at the local level. The second reason is that the concept of flood protection by the technical infrastructure is dominated in flood risk management policy and no attention is paid to integrated flood risk management based on the entire river basin. Thirdly, there are some uncertainties regarding the delimitation of the inundation area and the decision not to issue a building permit, which puts municipal building authorities under pressure to permit the building of residential houses and buildings for economic activities, even in flood-prone areas.

Thus, the analysis showed that the expectation that the spatial plans of the municipalities could contribute to effective flood risk management in the rural landscape was not met. Due to the changing climate and the growing flood risk, however, it is necessary to strengthen the importance of municipal spatial plans from the point of view of flood risk management in a rural landscape. The way to this is through the decentralisation of flood risk management in SR and a change the paradigm of flood policy from flood protection to increasing society's resilience to floods.

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