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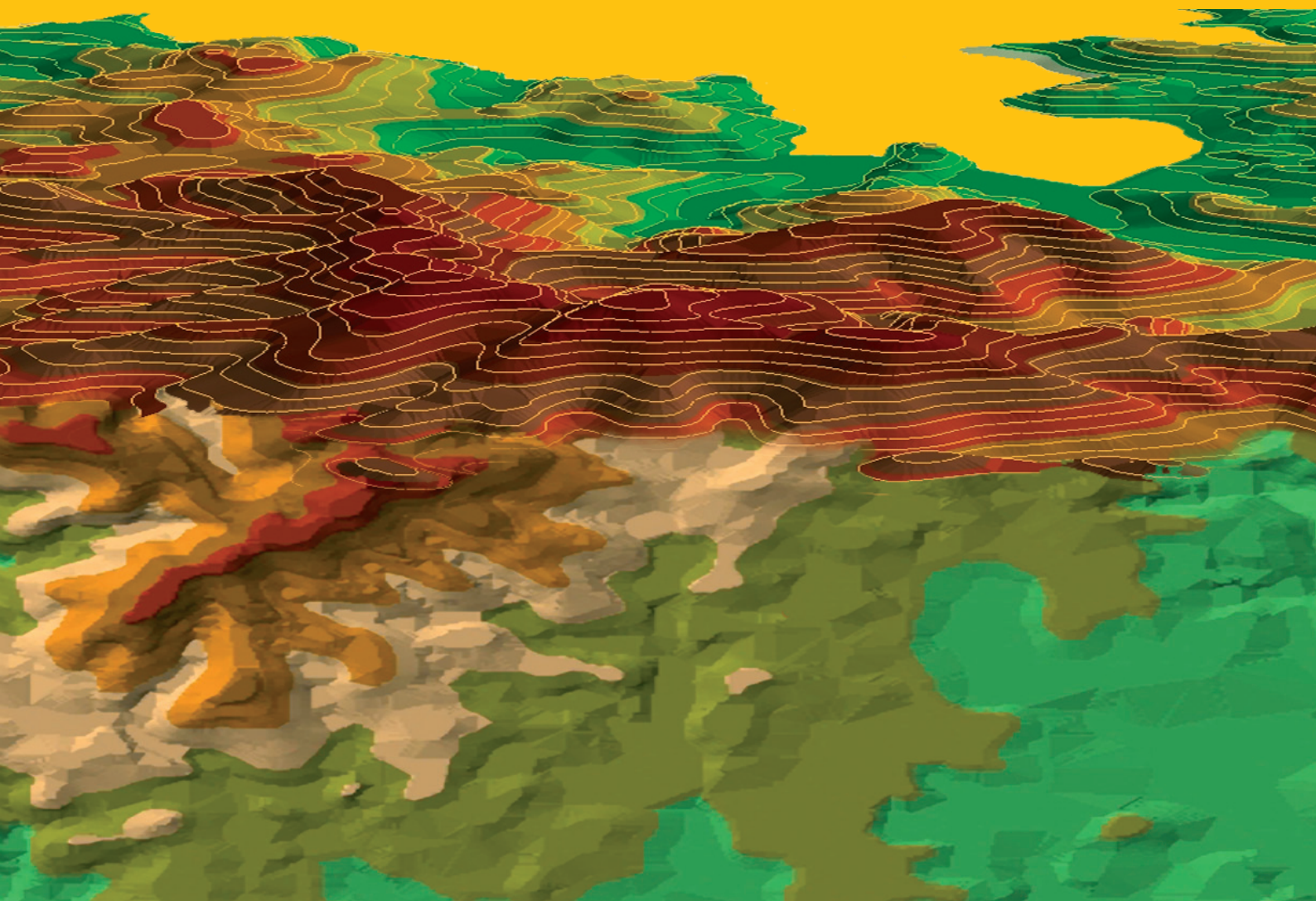

Fig. 4: Modern terrased vineyards in Selešťany (Photo: D. Štefunková)

Fig. 5: Stone mounds – a remnants of traditional vineyards that are now abandoned and overgrown by forest in Modra (Photo: J. Hanušin)

Illustrations related to the paper by D. Štefunková and J. Hanušin

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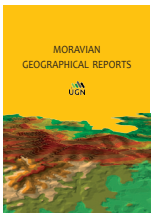

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Assessment of territorial benefits and efficiency from the construction of motorway and speed train networks: The Czech case

Karel MAIER [a], Daniel FRANKE [a *]

Abstract

The Czech Republic has been developing its motorway network since the 1970s, while efforts to upgrade its railway system from the 1990s have been limited to improvements of existing major lines. Only recently has the government decided to construct new "speed connection" rail lines. This article investigates the possible territorial benefits from the future development of planned motorways and of various speed connection railway options. The modelling is based on Huff´s gravity model that calculates the benefits from improved accessibility, to job and service centres for residents of each municipality. The modelling outcomes are used to compare planned motorway development and rail development options with respect to their efficiency, related to the investment and potential numbers of users.

Keywords: *transportation infrastructure; spatial planning; job accessibility; speed rail connections; gravity model; Czech Republic*

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1. Introduction

1.1 Background

Czech Republic has made reasonable progress in building its motorway network in the last two decades, but the density of motorways remains lower than in neighbouring Germany and Austria, for example. Plans for the construction of new motorways are fixed in spatial plans and, with some delays caused mostly by lengthy procedures of acquiring land and conflicts with nature preservation, they are implemented.

Unlike many European countries which have been developing their national high-speed rail network, contributing in this way to an emerging continental high-speed train system, the development of the Czech rail infrastructure is quite delayed. The Republic inherited a very dense network of railways originating mostly from the 19th century, but their quality and speed are behind contemporary European standards. The most important rail connections to neighbouring metropoles in Austria, Germany, Slovakia and Poland were upgraded in the last twenty years, but maximum speeds on the improved sections do not exceed 160 km.h^{-1} and are often below 100 km.h^{-1}. Improved quality is planned for upgrading other lines from Prague to Bavaria and Upper Austria, but the speed of these upgrades is considerably slower than motorway construction, shifting a larger share of traffic load to the road networks.

Recent experiences with congested motorways, especially in the metropolitan area of Prague and on the main route between Prague and Brno, show that individual car transportation as well as bus service dependent on the same roadways as cars, cannot be effective solutions to ever-increasing transportation needs. On the other hand, even the recent small improvements in rail service on some lines proves that passengers will easily shift from unpredictable driving to reliable, comfortable and comparatively fast rail offerings whenever adequate services are available. Consequently, ridership on the Czech railways has been steadily increasing since 2010 when the company started to run new trains on improved tracks (ČTK, 2018). Nevertheless, a rail system compatible with 21st century technologies and competitive with road and air transport remains an ideal objective, and only recently has such a system gained governmental support which may result in implementation. Nonetheless, doubts about the efficiency of investments in the development of

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high-speed railways in the Czech Republic still occur. The country is rather small, with only the national capital of Prague exceeding one million inhabitants and regional population centres (Brno, Ostrava, Plzeň) with populations between 150 and 350 thousand. Distances between these centres are between 100 and 200 kilometres. Based on existing data, the volumes of international passengers cannot sustain the project economically, even if a partial shift of current air passengers for Frankfurt, Berlin, Vienna, Budapest, etc., is considered. All considered, this situation hardly allows for the development of the virtues of a high-speed rail network as an independent system. Therefore, the Ministry of Transportation abandoned the original idea of separated high-speed railways derived from the French, Spanish or Italian models, in favour of the hybrid system of "speed connections" (RS, rychlá spojení), interconnected with the existing, upgraded standard railway network. This would allow the deviation of some trains from the speed connection line to service smaller cities and their hinterlands along standard railways. The number of passengers may increase significantly with daily and other frequent commuting from smaller places to major centres by trains that will combine their journey on speed and standard rail systems.

Plans for the speed connection network have not been stabilised yet. Corridors of the proposed lines partly follow (recently and currently) improved major standard railway lines, which may make it possible to combine service on uncompleted speed connection sections with these improved standard sections or to use the standard railways to bypass the speed rail during repairs (cf. Šlegr, 2012, pp. 104–108).

1.2 Objectives of the research

Most previous studies in this area have analysed the costs of a new investment in a single road, motorway or railway separately, comparing them to the benefits of saved passenger time and increased revenue from passenger fares and cargo payments. One objective of this research project was to enlarge the benefit assessment – from costs and time savings brought about by alternative plans to considerations of their territorial impact, at least with respect to residences. This aim is represented by the increased attractiveness of residential "source" locations induced by improved access to and from jobs and services in central places ("destination centres"). Improved speed of travel will enlarge the pool of places from which commuters may reach major cities with a wide variety of jobs and services, and this is considered as a major engine for the change in attractiveness of these source places. Additionally, the enlarged coverage of smaller centres connected with new or improved transportation infrastructure, will contribute to overlapping the commuter areas of different centres, increasing individual choices of access to different centres with different jobs and services. These two effects, i.e. an enlarged commuter area to major centres, and the wider variety of accessible smaller centres, create the territorial benefit of the transport infrastructure improvements.

As various modes of transportation can contribute to improved accessibility and improved transportation infrastructures can serve various areas of the country, the main task of this research project was to compare the benefit differential from investment options in different transportation modes and lines, rather than to quantify the benefits in absolute terms.

2. Theoretical overview

The attractiveness of a place is an outcome of its qualities as appreciated by its users. In a market economy, such an indicator can be expressed by property (housing, commercial, industrial, etc.) prices that indicate the use value of sites and structures built upon them, as an endogenous relationship because accessibility capitalises as property prices (cf. Osland and Thorsen, 2013). This immediate and simple methodology obviously cannot be used for the assessment of attractiveness in the future. In such cases, an indirect method of modelling can be applied that incorporates opportunities related to the labour market and service centres. The method assesses the change of attractiveness of a place for residents (attributes of the locations of origin) by calculating the time differential for accessing destinations of everyday use, such as jobs and facilities providing services (attributes of the locations of destination). These attributes, together with the friction of distance between origins and destinations, express the fact that an increasing spatial or temporal remoteness of two places implicates declining relations between them (Rodrigue et al., 2017; Huff and Jenks, 1968; Seidenglanz, 2008).

The dependence of an indicator of living place attractiveness on the spatial accessibility of jobs and services derives from trade-off theory (Balchin et al., 1988, pp. 50–52; O´Farrell and Markham, 1975). This theory accounts for the spatial behaviour of households optimising the location of their residence by minimising the total costs for housing and commuting (measured in time and fares) against the quality of housing. Consequently, the spatial accessibility of a place can be defined as the potential that a variety of activities, services and job opportunities could be made available from the place within a certain interval of physical or time distance. Accessibility is strongly tied to the means of mobility available in any area in question (Hanson, 2004). The available modes of transportation strongly affect the settlement pattern. As such, the history of settlement change is closely intertwined with the development of transportation technology, at least from the time when people started to live beyond walking distances from job places during the Industrial Revolution. Adams (1970) has distinguished the walking-horsecar, electric streetcar, automobile and freeway eras. While the speed of transportation means limited the former eras to a local scale only, the automobile era crossed the limits to suburbia, and the freeway era shifted the scale of commuting to a regional tier. Kraft (2012, pp. 3–4) defines three basic types of criteria for the settlement hierarchy: accessibility of the nodes, infrastructure endowment and size-relevant features. The future era of high-speed railways will follow the trend of increasing the spatial scale of commuting but, much more than the freeway era, will result in increased disparities between serviced centres and by-passed areas, as described by Creswell (2010, pp. 24–25).

The development of a new quality transport infrastructure affects the spatial pattern of accessibility in the area, resulting in changes in the time needed to access destinations. Certain authors warn against excessive technological determinism (Coe et al., 2007), however, but it is reasonable to assume that projects for a new or upgraded transport infrastructure will induce changes in the spatial behaviours of both inhabitants and businesses and, consequently, changes in attractiveness within and among particular regions and places.

Transport strategies as means to improve spatial accessibility and, consequently, to enhance regional economies through the improved attractiveness of places, have been studied by Geurs et al. (2010) *inter alia*. Many authors have investigated the spatial effects of improved transportation on house and rent prices at the city or regional level (cf. Grimes and Young, 2013). Normatively, the issue of spatial equity in transport strategies has been raised by Lucas et al. (2016).

The modelling of accessibility and its changes has used several different approaches. Some have used graph theory (Black, 2003; Brinke, 1999). Traffic volumes are determined from the supply side by parameters of the transport infrastructure, but they also rely on the demand raised by individual mobility strategies, preferences and capabilities of persons (Geurs and van Wee, 2004). Condeço-Melhorado et al. (2014) provide a comprehensive survey of modelling applications and methodological issues related to accessibility and spatial interaction.

Methods for accessibility measurement often mix normative and positive approaches, i.e. they establish a general normative measure (derived from empirical research on the behaviours of people) to bridge the gaps in data on the behaviour of individuals (Páez et al., 2012). Gravity models (e.g. Hansen, 1959; Huff, 1963; Wilson, 1967; Ingram, 1971; Reif, 1973; Sen and Smith, 1995; Bruinsma–Rietveld, 1998) represent tools to both appraise present spatial relations and interactions, and to predict their future change. One type of gravity model is the potential model that measures interactions between a single location and every other location (Rodrigue et al., 2017). Gravity (potential) models overcome the absence of empirical data on the future attractiveness of places. For existing attractiveness, they may be validated by comparison with actual property price differentials in various places. Relevant studies dealing with the applications of gravity models were published in international fora by Cochrane (1975), McArthur et al. (2011), Mikkonen and Luoma (1999), Christie (2001), Khadaroo and Seetanah (2008), and Tsekeris and Stathopoulos (2006). With respect to the Czechoslovakian and subsequently Czech research, several authors have elaborated the theoretical level (e.g. Pavlík and Kühnl, 1981; Bezák, 1975), as well as applications of the gravity model in geography or economics (e.g. Hampl, 2005; Maryáš, 1983; Marada et al., 2010).

3. Methodology and data

The methodology in this report uses the body of theoretical work described above. It presumes that public benefits result from building new transport infrastructures, consisting of improved accessibility to centres providing jobs and facilities with higher rank "supra-local" services for residents. The improved accessibility results in a higher attractiveness for the places of residence that are affected by the improved infrastructure.

3.1 Accessibility

The gravity potential was applied for the modelling of accessibility, assessing benefit differentials for various options of infrastructure improvements. The accessibility from a source place (the origin location of commuting) is represented by a matrix of potential interactions with all destination centres (the targets of commuting) within the area of potential access. The resulting changed attractiveness is quantified with differentials of the units of benefit from changed accessibility.

3.2 Identification of commuting sources and destinations

The source places/locations from which residents commute to centres are represented by all communities/municipalities. As the size of the "source" communities/municipalities is usually small (an average Czech community/municipality as an administrative unit, including the 1.25 million residents of Prague, accounts for about 1,630 inhabitants, with a median of 380 inhabitants), this provides enough detailed information for the national size of this survey. The relevant census data on population and commuters were attached to the GIS reference points of the municipalities. This approach is reasonable for small towns and villages (which prevail among Czech municipalities), but in large cities it tends to underestimate real time accessibility as the model does not calculate local transport within the cities. On the other hand, the willingness to commute to large cities distorts the distance decay functions by acceptance of longer commuting times, as well as a variety of other factors influencing the willingness to commute among different age groups, gender, and particularly the education status of commuters (cf. Johansson et al., 2002; Heldt Cassel et al., 2013).

The selection of destination centres in the Czech Republic followed the commuter-based regionalisation of the Czech Republic (Mulíček et al., 2011; Sýkora and Mulíček, 2009; Sýkora and Mulíček, 2012) that resulted in the determination of the micro-regional job centres. The micro-regional job centres and their relevant catchment areas were established using data on job commuting: the catchment areas had to have at least 1,000 occupied job places and had to be the primary destination for commuters from at least one of the municipalities in the commuting area. A total of 260 micro-regional job centres were identified for 2001 (Sýkora and Mulíček, 2009). For the needs of this project the original methodology was reworked by updating the data using the Census of 2011, resulting in 234 micro-regional job centres.

To depict cross-border relationships, foreign destination centres were considered if they were located at distances of up to about 100 kilometres by road or rail from the Czech border, and with a population minimum at 50,000 inhabitants. In addition, to assess the impact of the construction of motorways and the speed connection rail lines, Central European metropolises of international importance situated at a greater distance (than 100 km from the border) were incorporated in the model, namely Budapest, Frankfurt (M), Leipzig, Stuttgart, Berlin, Cologne and Düsseldorf. For these cases, the calculation of the benefit from time savings was not confined by the distance decay curve.

For the calculation of commuting time, the model considered as destination reference points, the railway / bus station or point on the road communications nearest to the reference point of the relevant central municipality.

The significance of the destination job and service centres was defined using the indicator of "centre comprehensive size" ("komplexní velikost" (KV): Hampl et al., 2005; Kraft and Vančura, 2009). The "centre comprehensive size" is calculated as one-third of the (sum of the share of the centre in question with respect to the national population PLUS a doubled share of the centre in question with respect to national jobs), multiplied by 10,000:

$$KV = \frac{\frac{POP_C}{POP_{CR}} + 2 \times \frac{OPM_C}{OPM_{CR}}}{3} \times 10{,}000$$

where POP_C = population of the centre, POP_{CR} = population of the Czech Republic, OPM_C = occupied job places in the centre, and OPM_{CR} = occupied job places of the Czech Republic.

For the centres outside of the Czech Republic, where the data on occupied job places were not available, a regression function based on their population size was used for determination of their comprehensive sizes. The function derives from the relationship between population and job size in Czech centres, which is demonstrated in Figure 1.

3.3 Distance decay

The concept of distance decay is useful for modelling the effects on accessibility through an improvement in transport infrastructure and, as a result, attractiveness of the territory (Wheeler and Muller, 1981; Spiekermann and Wegener, 2007; Tse et al., 2003; Hanly and Dargay, 2003; van Wee, 2001; Rouwendal, 1999). The distance decay function depicts how increasing time distances between places decrease the volume of interactions between them:

$$Distance\ decay(t)=(1 - \Phi[(t(x) - \mu) / \sigma])$$

where t = travel time, $\Phi[(t(x) - \mu)/\sigma]$ = distribution function of the normal distribution N (μ, σ^2), μ = median and σ = standard variation/deviation.

For Czech conditions, Novotný et al. (2008) and later Novotný (2011) elaborated the concept of distance decay for daily commuting, based on his own detailed research on commuting behaviours in Central Bohemia and with reference to national census data (see Fig. 2).

For some routes, the distance decay function will be affected by other physical, social and technological factors in addition to the friction of distance effects. It can be also modified for individual social groups of commuters and by different objectives or purposes (variety of job positions, various grades of education facilities, hierarchical position of services and health care, etc.). The overall country-wide scale and the long time period in which the expected projects as well as the changes imposed by them will occur, however, makes the use of the general decay curve calculated by Novotný (2011) acceptable. The country-wide scale, where only relations between individual centres are studied, also makes it acceptable to ignore the time-distance relations within urban areas, which obviously may be different in various cases of cities and urban areas. The final model will not follow the recommendation of Johansson et al. (2002) to split the accessibility measure into parts on three different spatial levels.

3.4 Attractiveness of a place

The attractiveness of a place is calculated as a sum of the accessibilities to destination centres within the time distance relevant for commuting, reduced by distance decay:

$$Attractiveness\ of\ the\ place_i = \sum_{j=1}^{n}(KV_j \times distance\ decay[t_{ij}])$$

where KV = centre comprehensive size, i = the municipality for which the probability of selection as a destination centre is calculated, j = commuting destination centre, n = total number of destination centres, including the centre j and t = travel time.

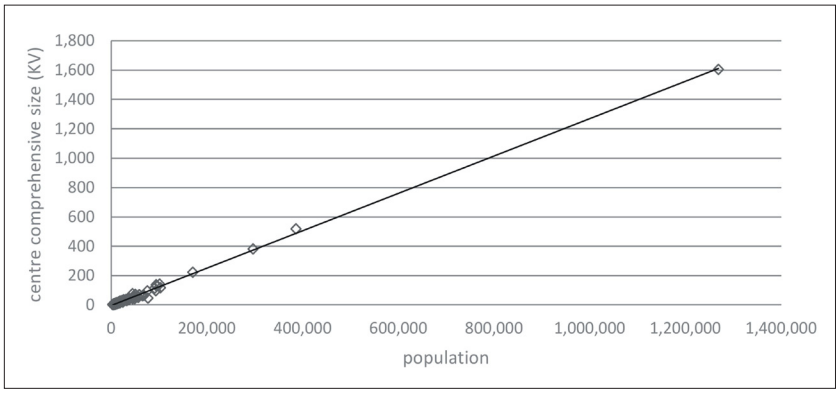

Fig. 1: Regression function for population and comprehensive size (KV) of Czech job centres: y = 0.0013(population) – 2.7826; R^2 = 0.9972. Source: authors' calculations*

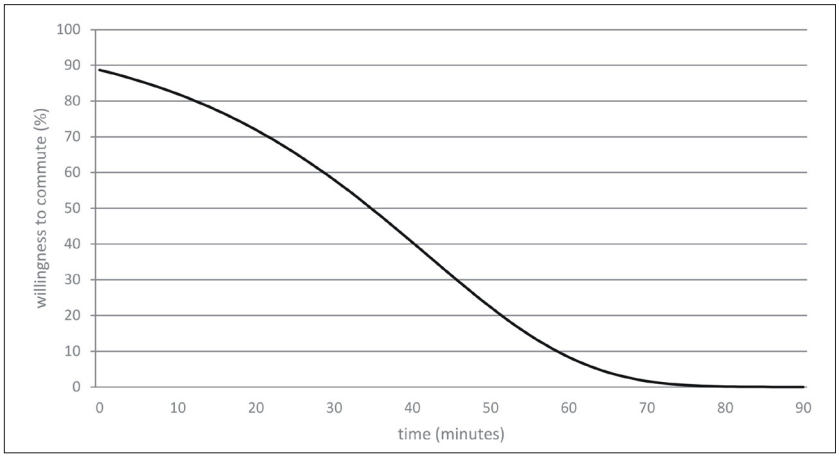

Fig. 2: The distance decay curve. Sources: Novotný et al., 2008; Novotný, 2011

The result of the calculation indicates the (change of) attractiveness of a place. It is a dimensionless quantity that expresses the effect of the change in transport on spatial accessibility of all destination centres in question. The better the accessibility of the territory, related both to the accessibility of transport infrastructure and the time accessibility of the accessible target centres, the higher the attractiveness of the territory in question.

3.5 Calibrated benefits

Calibrated benefit is calculated for each municipality. The calibrated benefits are attached to the source places of municipalities as well as destination centres, and the KV of the destination centres makes calibration. Benefits for larger territorial units up to the whole country equate to the sum of calibrated benefits of all municipalities within the territory in question.

$$Calibrated\ benefit = \frac{((Attr.perspective - Attr.existing) \times population)}{10,000}$$

$$benefit = \sum calibrated\ benefits$$

where Attr. perspective = attractiveness of the place after the accessibility has been improved, Attr. existing = attractiveness of the place before the accessibility has been improved and population = population affected by the improved accessibility.

The calibrated benefit quantified by the units of benefit can be calculated also for individual demographic and socio-economic groups, such as age groups, educational levels, etc. In such a case, the population data in the formula above should be replaced with the population of the relevant group.

The outcome of the benefit calculation is a value expressed as "units of benefit", of dimensionless quantity, that reflects the effects of the changing accessibility of centres on the spatial pattern of attractiveness. The unit of benefit value allows for the comparison of the benefits among various options of transportation infrastructure.

For destination centres as job and service providers, the model considers the demand for jobs and services, *ceteris paribus*, constant within the national territory, and thus it neglects any possible secondary effects of emerging new jobs and services at more attractive centres, without their compensation by reduction elsewhere. As such, with respect to jobs and services the model is zero-sum based.

3.6 Spatial equity of the benefit distribution

The 'equity of benefits' distribution from increased accessibility among various individuals and social groups is often discussed (Manderscheid, 2009). Obviously, with new infrastructures that serve only certain hubs and bypass other areas, a gap between the accessibility of the serviced areas and those bypassed will emerge. In practice, this issue is rarely raised in evaluations of transportation projects, as they often do not explicitly consider social and spatial equity (Keeling, 2008). Lucas et al. (2015) recommend the use of the Gini index as a scale-independent measure for equity of accessibility. The use of this method is quite frequent for assessment of various inequalities in benefit distribution: for spatial distribution issues, see Murray and Davis (2001), Delbosc and Currie (2011), Welch and Mishra (2013). The coefficient expresses the ratio of the area between the area under the line of equality and the calculated Lorenz curve (area A) with the total area under the line of equality (area A + B). The Gini Coefficient can be expressed by the equation: G = A / (A + B) (e.g. Rodrigue et al., 2017). In our case, the graph-based method using the Lorenz curve and the Gini index was used in order to assess the spatial equity of the commuters' benefits from improved rail infrastructure – and to compare it with motorway construction.

3.7 Investment costs

To compare the effectiveness of the model options, the relation between the relevant costs must be complemented by the relations with their benefits. The costs side was reduced to only the infrastructure investment, without considering subsequent running and maintenance costs.

This simplification provides only a 'rough' estimate, but it is made reasonable by the fact that the purpose of the analysis was just to identify the benefit differentials between the model options, which will probably compensate for the errors under any options. As detailed budgets of source data on investment costs are missing for prospective projects, which are mostly at the preliminary stage, the general price standards were used.

The investment costs for roads and motorways were calculated from the price standards of ŘSD (2013). They distinguish the costs for motorways, speed roads (recently renamed as 2nd class motorways), national 1st class roads, 2nd class roads, etc.

The investment costs for rail construction and improvements were calculated from the general price standards for rail investments by Robeš and Zeman (2003). These standards classify the investment costs to new single-track and double-track railways, electrified and non-electrified, and they also rate the upgrading of existing railways and construction of additional track to existing railways. The costs for station improvements were added to the general cost by a coefficient.

For both the road and rail construction costs, additional costs for tunnels and bridges were not considered. This is reasoned by approximately the same share of these constructions per 100 kms in the options, which would eliminate the costs in the differential.

4. Model options and relevant travel times

The assessment model was structured into road and rail sections, with levels of development in the rail sections, and with options related to currently discussed variants of the routing.

4.1 Road transport section

The road transport section of the model follows the policy of motorway construction and the improving of existing main road arteries that is generally accepted and fixed in spatial plans. There are some alternative partial sections of routing but their eventual choice will not affect significantly the change of travel times when the project is completed. As such, the part of the model related to road transport dealt only with the initial (2017) state and final situation as designed in plans and projects (ŘSD, 2016).

Network data OpenStreetMap was used to calculate road distances. OpenStreetMap data was selected based on an up-to-date network dataset with cross-border links to foreign centres. The use of OpenStreetMap for network analysis was evaluated with respect to the completeness and accuracy of data for network analysis (Graser et al., 2015; Brovelli et al., 2017). The information on projects for upgraded roads

and new motorways was made available by the Road and Motorway Directorate (Ředitelství silnic a dálnic, ŘSD). Sections of the network were adjusted by the tools of GIS: Split Lines at Points, Snap, etc.

For calculating time distance by individual cars, a model speed was attached to each road section, following the outcomes of the research by Hudeček (2010). To include the physical factors of the friction of distance, the category of road, the number of lanes and the longitudinal tilt were accounted for. The model speed was also reduced for sections passing through built-up areas.

Customised data OpenStreetMap was used also for bus service. From the road network, only those sections used by regular bus service were considered. Bus routes were obtained from the national information system on timetables using the comprehensive set of localised public transport stops. The average travel speed of buses was modified from the individual car transport with respect to the delay in the intermediate stops by a coefficient of 0.5 for local feeder buses, which was validated on various routes. The new plans for road infrastructure improvement are depicted in Figure 3.

4.2 Rail transport section

The modelling for rail transport was more complex. Three levels of rail infrastructure development were used as a basis for the model options. Level A consisted in upgrading of major lines by their straightening and building second tracks for presently single-track lines. It implies both the completion of the currently executed projects and the new projects purported by the Ministry of Transportation. The level B adds new speed connection lines to level A. It splits into five alternative options, The B1 option is based on corridors for the speed connection lines and further improvements on existing rail infrastructure as they are anchored in spatial planning documents for regions (namely Development Principles [Zásady územního rozvoje], ZÚR). The other options (B2 to B5) assess alternatives to some of the corridors and they also bring additional new ideas of speed connections studied by the Management of Railway Infrastructure (Správa železniční dopravní cesty, SŽDC) by order of the Ministry of Transportation (SŽDC, 2010; SŽDC, 2014). Level C adds some projects that have been studied as a long-term vision: it was also elaborated in alternative options (C1, C2).

The maps ArcČR500 and OpenStreetMap provided the geographic data on the rail network. The location of stations was kindly provided by the CEDA company, Ltd. Typical travel times from timetables were considered for each section of railway for the calculation of time distance. The data were received from machine-readable timetables developed by the CHAPS Company. In the next step, a specialised GTFS (General Transit Feed Specification) file was created, which consisted of several text files. The received model travel times were tested on a pilot area of the Prague integrated transport system, which covers a great deal of the commuter area of Prague.

The travel times for the future new or upgraded rail lines were received from relevant projects and studies that had been elaborated for the Ministry of Transport and the SŽDC). Figure 4 depicts the levels of rail infrastructure improvement and alternative options within the levels.

5. Results: Assessment of model options

The results of the modelling identify those places with an uneven increase of attractiveness, as a starting point for the assessment of benefit for territorial units as well as for the whole country, and to aid in reasoning with respect to efficiencies of alternatives.

5.1 Road transport

The existing pattern of motorways results in central Bohemia as the most attractive area, followed by the three-pole chain of Brno, central Moravia and Ostrava regions in Moravia. This is caused by the concentration of motorways as well as high density populations in these regions. The planned new motorways will connect less populated regions to these central areas. As such, they will strengthen the attractiveness of the Prague metropolitan area and, to a lesser extent, other metropolitan areas, but the low

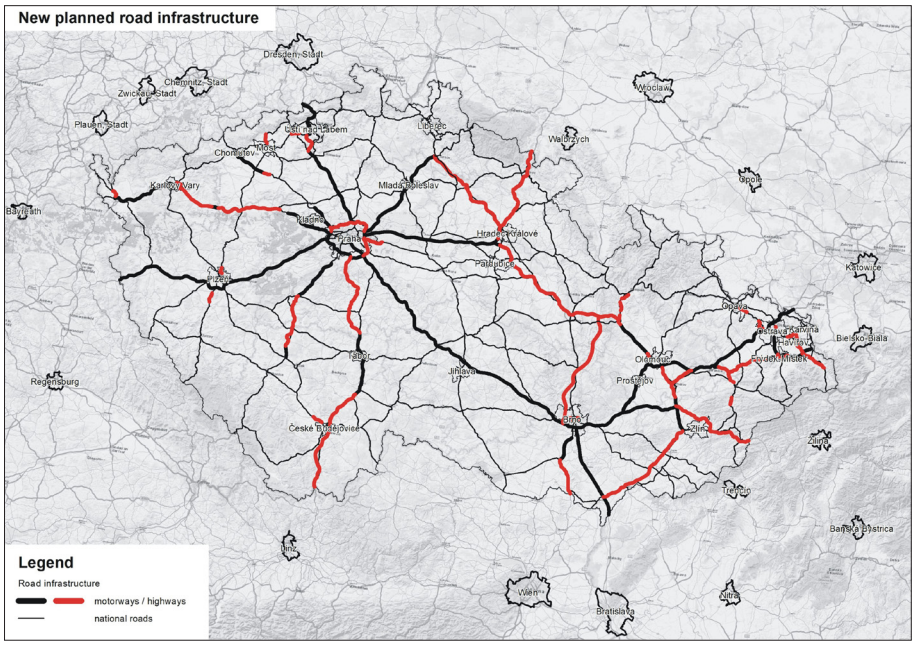

Fig. 3: Existing and new planned road infrastructure
Sources: ŘSD, 2013; ŘSD, 2016

population density in the newly serviced areas will make the total increase of benefit from their improved accessibility much less than the already accomplished benefits from the motorways currently in service.

The benefit from increased attractiveness with improved accessibility covers almost all the territory of the country, but, in the case of about 60% of it, the increase is below 2,500 units of benefit compared to the present values for central Bohemia, reaching between 1 and 1.7 million units (see Fig. 5). The average unitary increase of benefit related to 1 km of a new motorway is 2,518 units, and the estimated increase in the attractiveness index from CZK 1 million investment (prices as of 2017) will result in 16.36 units. This is much less compared to the previous increases in benefits created by the construction of the already existing network of motorways since the 1970s: The increase in existing accessibility compared to the accessibility before the first motorway had been opened is registered as much as 12,886 units of benefit per 1 km of motorway, with a 64.43 units increase in the attractiveness index from CZK 1 million investment (prices as of 2017). Such a comparison of future benefits from the planned to the already existing motorways suggests that the law of diminishing marginal utility strongly applies.

5.2 Rail transport

At present, the low speed of trains on existing railways limits the competitiveness of rail transportation only to the immediate hinterlands of some major job centres, mostly where trains can reach the city centre from suburban stations more quickly than road transport that is affected by traffic congestion. As such, current rail transport can contribute to the attractiveness of places by time

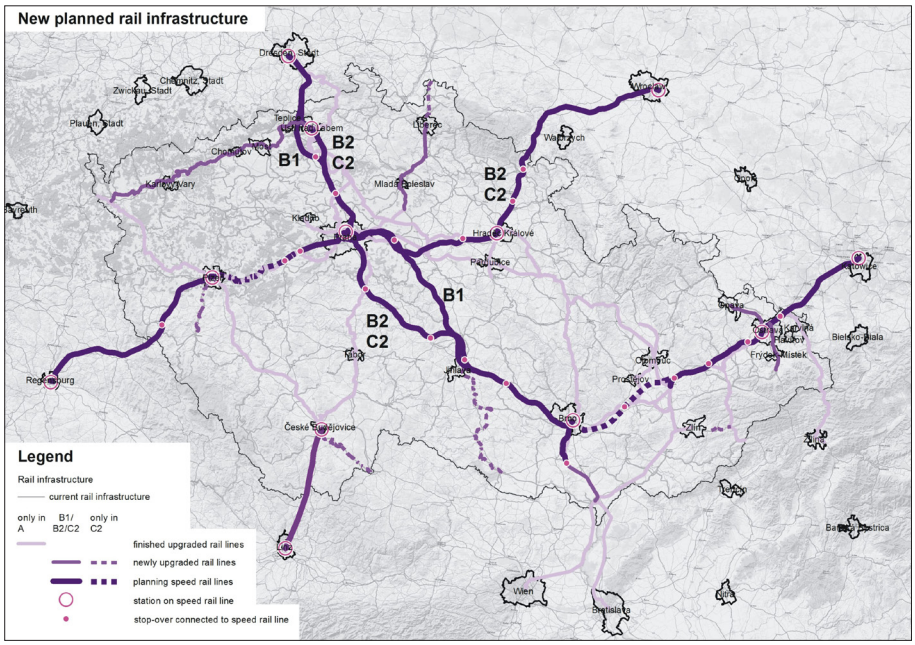

Fig. 4: Existing and new planned rail infrastructure
Sources: ŘSD, 2013; ŘSD, 2016

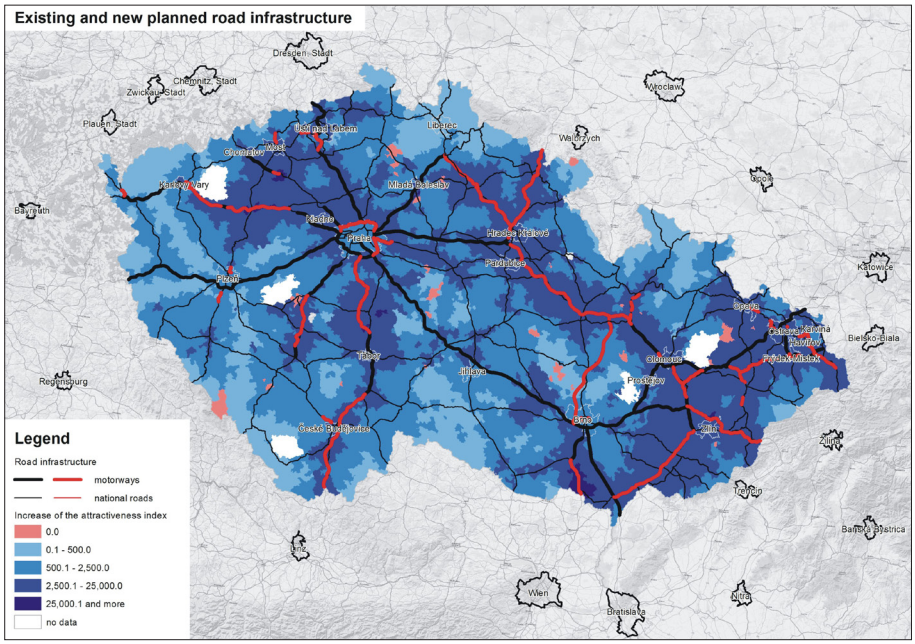

Fig. 5: Territorial benefits from the new planned road infrastructure
Sources: data by ŘSD 2013, 2016; authors' calculations

accessibility only in exceptional cases. The attractiveness induced by rail transportation is currently highest in Prague with its immediate hinterlands (smaller metropolitan area), with values of 1 to 1.7 million units of benefit, while the values for the Brno and Ostrava metropolitan areas do not exceed 50,000. The spread of attractiveness is much less than in the case of motorways.

The model has shown that the larger centres situated on hubs of upgraded or new speed railways will profit from an increased pool of places within commuting time distance, and suburbanites will enjoy time savings to reach the centre.

The level A plan for rail transport improvement (upgrading of major lines) will improve rail accessibility along the upgraded lines, but it will not contribute much to the competitiveness of the rail system with road transport. The improved accessibility will contribute to the attractiveness of the affected centres by an increased choice of jobs and facilities offered by various centres on the line, but it may also undermine the functionality of smaller centres as providers of services and jobs due to the competition of larger and stronger centres, which will become easier to access.

The network of upgraded railways is rather sparse and the increase in speed on them is too small to affect larger parts of the country in significant ways. The model shows that it is only about 70% of the country's territory that is affected at all: i.e. with an increase in benefit above 500 units. Only about 10% of the territory demonstrates a significant increase – above 2,500 units. Large areas remain without improvement: namely the sparsely populated regions of Vysočina centred in Jihlava; North-Western Bohemia; the borderland areas of Silesia and the Bohemian Forest; as well as the urbanised region of Liberec with adjacent north-eastern Bohemia (see Fig. 6).

While territorial benefits will be unevenly distributed, the level A rail improvements will bring considerable total unitary increase of rail accessibility related to the extent and efficiency of the investment. The average benefit from 1 km of upgraded railway is 3,473 units, compared to 2,518 units in the case of finalising motorway plans. The benefits for increased attractiveness related to a CZK 1 million investment registers as 34.43 units, i.e. more than twice the benefits from the planned new motorways.

The benefits from the level B network of rail speed connection will be concentrated in the immediate surroundings of the serviced centres made accessible for commuting. The total increase of accessibility compared to the increase achieved by level A will be smaller than in all the studied alternative options, partly owing to a lesser frequency of the places served along the line.

Option B1 builds upon the projects anchored in regional spatial planning documents. Its positive effects cover the largest territory among the level B options, but it is less effective in the speed connection corridors as it counts on less by-pass stop-overs (Fig. 7). On the other hand, the B1 option is relatively less costly among the level B options, as it offers reasonably high total increase of benefit and its formal feasibility is supported by planning.

Option B2 is based on servicing the smaller centres by the speed connection railways (see Fig. 8). This option offers the highest increase in benefit, but it is, at the same time, more demanding in terms of investment costs.

Level C of rail network improvement presents long-term visions that provide full coverage of major centres with speed connection services. In the wider context of Central Europe, the Czech speed connection lines will fully support the relations Berlin–Vienna/Budapest; Munich–Warsaw; Vienna/Bratislava/Prague–Brno–Warsaw; Berlin–Linz–Adria. Additionally, new or improved existing "standard" lines linking some smaller centres to the speed connection lines will be planned. The results of the model assessment reveal the great potentials of speed rail connections, provided the travel speed on them reaches about 300 km.h^{-1}.

The alternative options C1 and C2 explore the effects of the variant connections Prague–Wroclaw via Hradec Králové or Liberec (Fig. 9). The assessment of their total territorial benefits proved that the difference between them is insignificant (but, of course, the spatial distribution of the benefit follows the alternative lines).

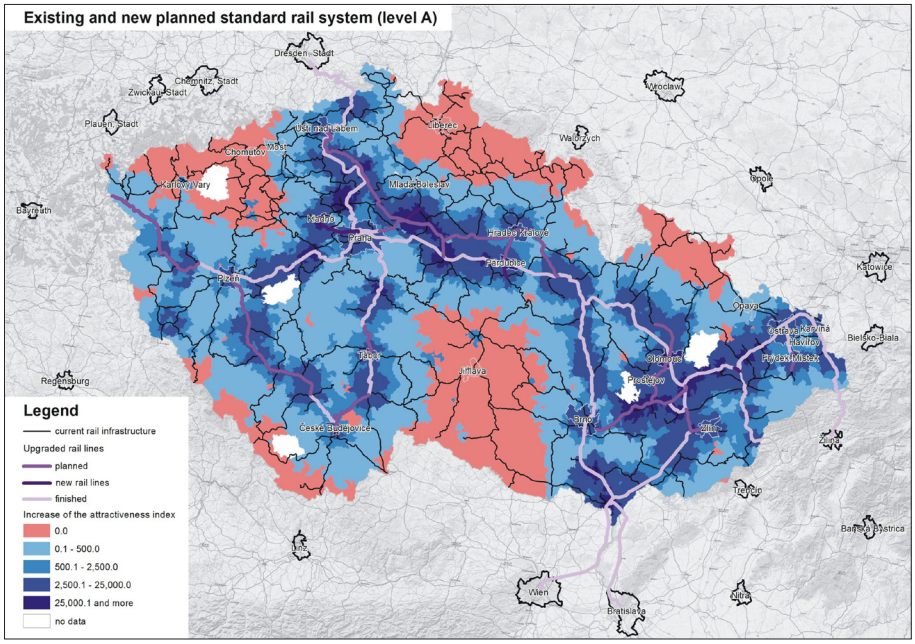

Fig. 6: Territorial benefit from the new planned rail infrastructure, level A
Sources: data by SŽDC, 2012; SŽDC, 2014; Šlegr, 2012; authors' calculations

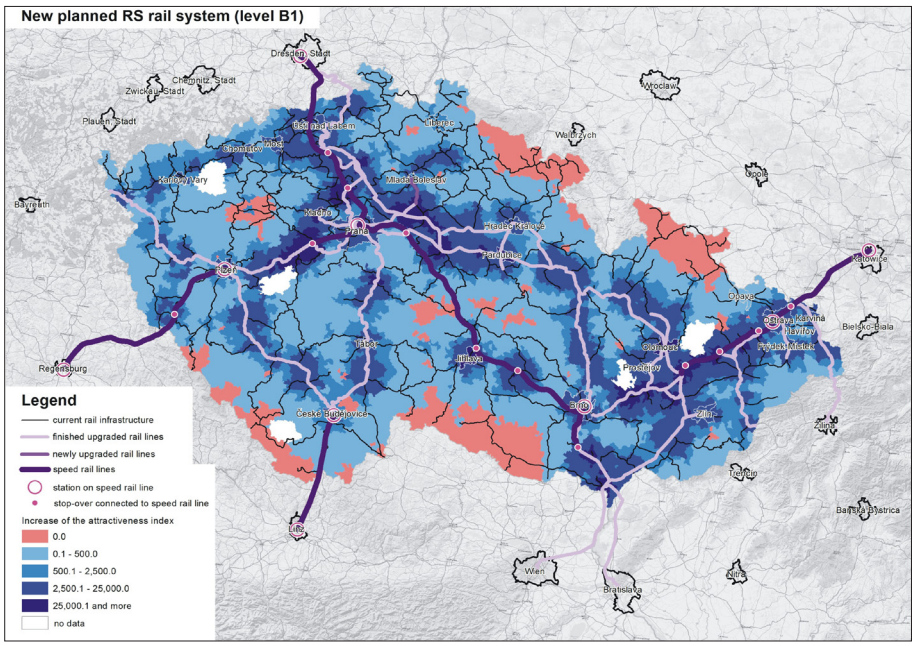

Fig. 7: Territorial benefit from the new planned rail infrastructure, option B1
Sources: data by SŽDC, 2012; SŽDC, 2014; Šlegr, 2012; authors' calculations

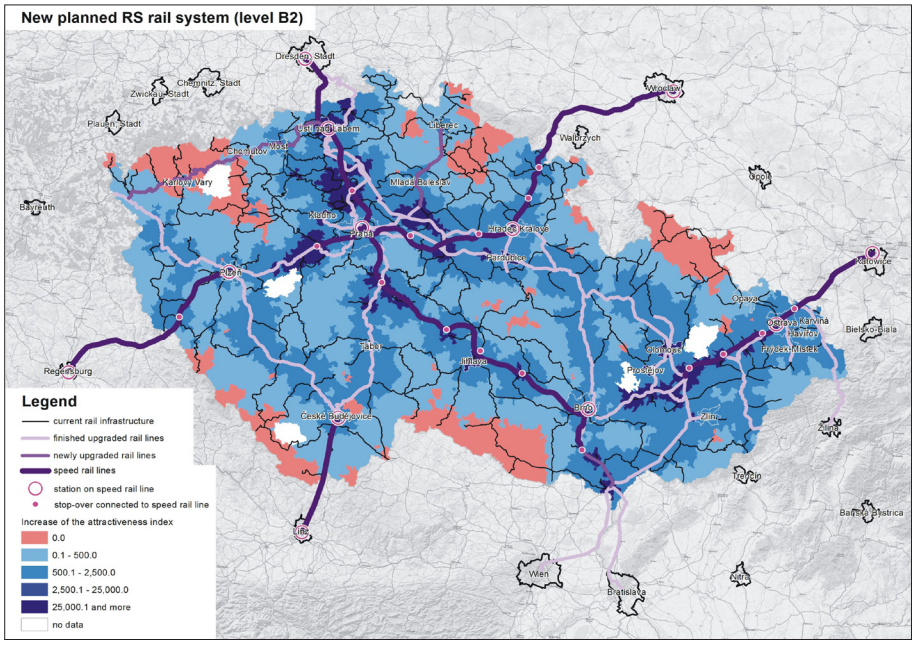

Fig. 8: Territorial benefit from the new planned rail infrastructure, option B2
Sources: data by SŽDC, 2012; SŽDC, 2014; Šlegr, 2012; authors' calculations

5.3 Benefits from and efficiency of the alternative options

A comparison of the alternative options in terms of their benefits and infrastructure investments and related investment costs is shown in Figure 10.

The comparison shows that the benefits from the model assessments prefer the rail investment to additional construction of motorways. The completion of the upgrading of standard rail lines is less costly and more beneficial for commuting than continuing motorway construction.

Comparisons from the point of view of increased unitary benefits induced by the various options and the marginal increase in efficiency from additional investments are depicted in Figure 11.

Apparently, the highest efficiency, i.e. largest increase of benefit units related to investment volumes, can be accomplished by the completion of upgrading the existing railways (level A). The marginal efficiency that describes the further increase of benefit units per unitary investment at level B varies significantly among the variant options but it is generally higher at level C.

5.4 Spatial equity of the benefit distribution

These options were tested for the spatial equity of benefits resulting from infrastructure improvement. Figure 12 shows the Lorenz curves for the planned motorway projects and for the A, B, C levels of rail development, with options B1, B2 and C2. The spatial distribution of benefit from new road infrastructure is

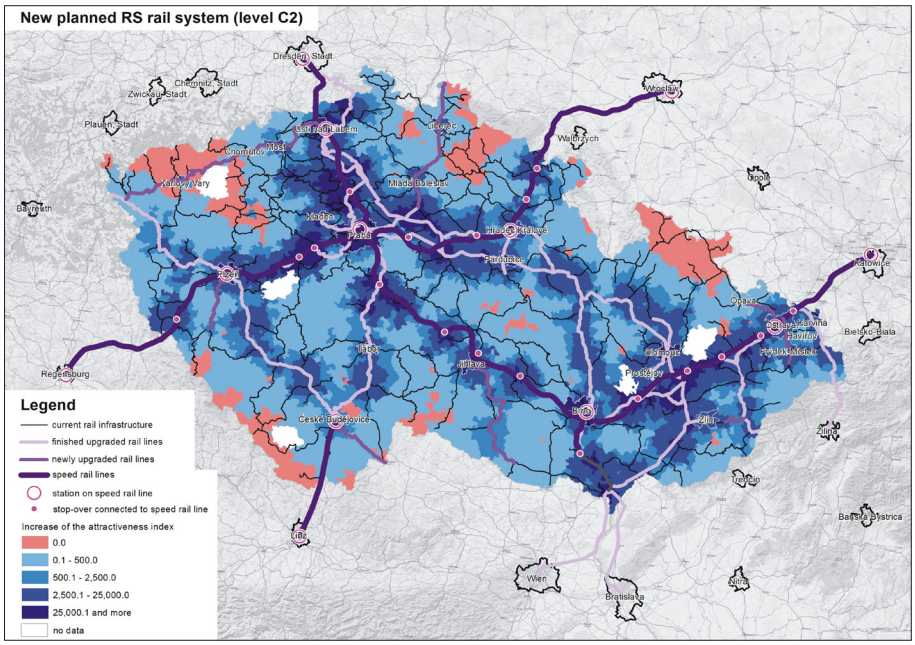

Fig. 9: Territorial benefit from the new planned rail infrastructure, option C2
Sources: data by SŽDC, 2012; SŽDC, 2014; Šlegr, 2012; authors' calculations

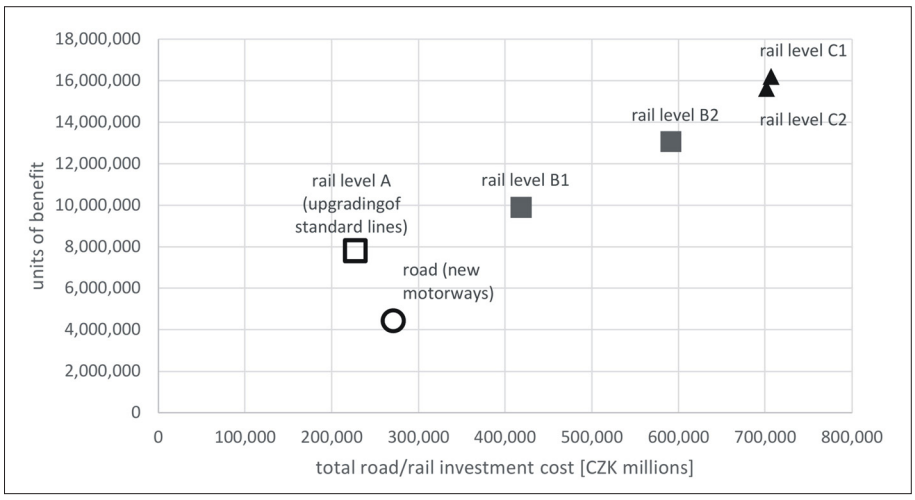

Fig. 10: Total benefits from the options of infrastructure investments related to their investment costs
Source: authors' calculations

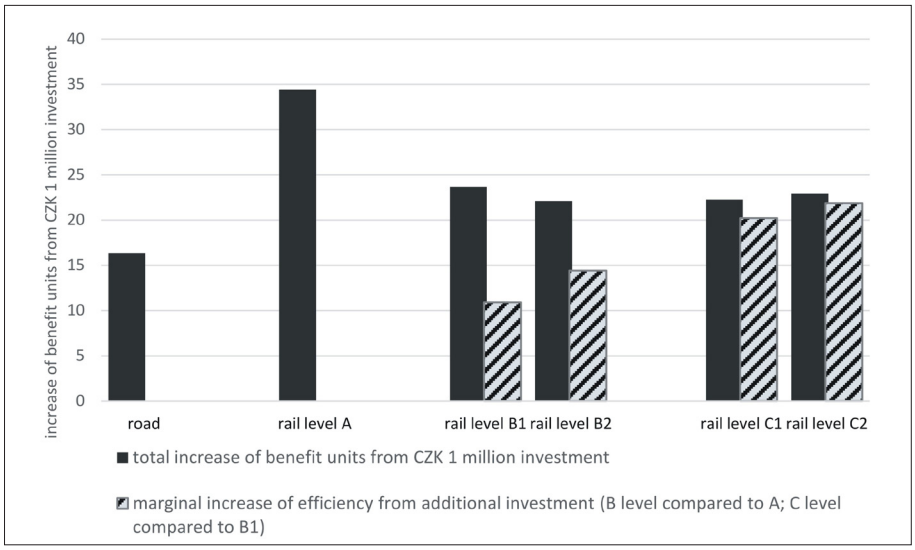

Fig. 11: Increased unitary benefit and marginal increase of efficiency induced by investment in transport infrastructure. Source: authors' calculations

less unequal than in the case of rail investments. The successive levels of development of speed connection railways tend to increase this spatial inequality.

The Gini index (Tab. 1) confirms the findings of the Lorenz curve. The spatial exclusivity of the benefits from increased accessibility by speed connection railways results in decreasing spatial equity with each additional speed connection line.

6. Discussion

The application of the gravity model in Huff´s interpretation, combined with the assessment of attractiveness by the "centre comprehensive size" (KV) and distance decay functions, proved to be useful in determining territorial benefits from changes induced by transportation investments.

This model was used for the assessment of territorial impact from the point of view of users such as daily commuters but it can be applied for any other users, e.g. non-daily commuters, day business trippers, distributors of perishable goods, etc., with adequately-defined distance decay curves. Hence, the focus of this application of the model on daily commuters considers only one segment of the benefits from new and/or improved transportation infrastructures; nevertheless, this segment is considered the most important, owing to the large and ever increasing numbers of commuters as witnessed by censuses (cf. Hudeček, 2010; Maier and Franke, 2015). Also, the size of the country and the fine grain of spread of its regional centres emphasise the importance of commuters among potential users.

The benefits calculated by the model consist of the commuters' time savings in the existing commuting catchment areas of the centres, plus the widened choice of centres to commute to within an acceptable time distance by increased speed on improved infrastructure. The calculation of benefits summarises the time savings for present commuters as well as the "new" accessibility of more distant centres, which widens the choice of centres accessible for commuting. This widened choice is increasingly important with prospects of volatile and even precarious job markets in the future (Korunka and Kubicek, 2017; Scherschel et al., 2012). The higher the increase in travel speed, the larger the time savings of present commuters and the wider the choice of additional centres. Thus, the increased benefits are commensurable with the population affected by the new or improved infrastructure and to the increase in travel speed/decrease in time spent travelling, resulting from it.

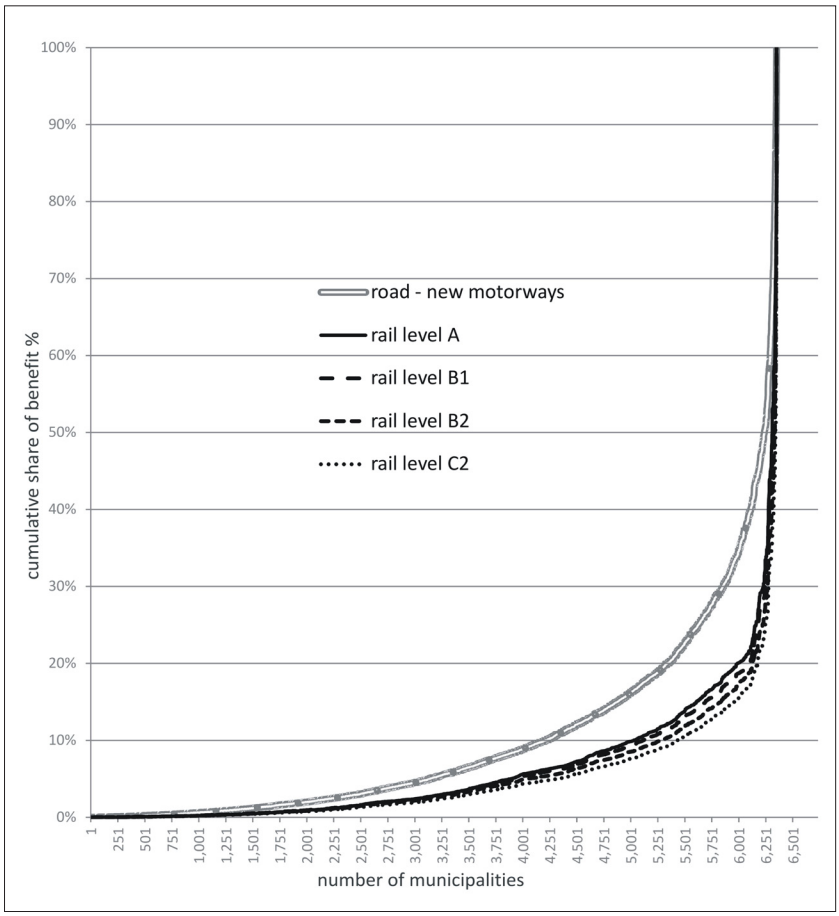

Fig. 12: Comparison of Lorenz curves for the benefits of motorway projects and rail options A, B1, B2 and C2
Source: authors' calculations

Level/option	Road – new motorways	Rail level A	Rail level B1	Rail level B2	Rail level C2
Value of Gini Index	0.5982	0.7571	0.7701	0.7901	0.8121

Tab. 1: Gini indexes for the benefits of motorway projects and rail options A, B1, B2 and C2
Source: authors' calculations

Following this line or argument, an effective optimisation of the benefitted population and the speed increase, both against the costs, will bring the highest benefit. This means that similar routes of the previously upgraded railways and the proposed speed connection lines may question the effectiveness of the speed connection system. Both infrastructures would serve the same pool of commuters and their benefits from time savings on the improved or new rail line for short travel distances may not be worth the costs, unless the increase in travel speed on the new infrastructure is significant. If the travel speed is less than 250 km.h^{-1}, the effect of speed connection lines would rather consist in creating new capacity for trains (Šlegr, 2012, p. 115). Besides, a low population density would also reduce the territorial benefit owing to fewer users. This may damage the benefit from increased travel speed in less populated regions. While the increased speed favours areas presently poorly served, the effect of multiple use privileges the densely populated areas, particularly large cities and towns.

The model used for the assessment has certain limitations. Firstly, it is rather static, as it does not consider the long-term effects of changed transportation accessibility on populations (in the "source" places) and jobs (in the job and service centres). As such, it also presupposes that the capacity of centres will be able to adjust to the served population. Obviously, the increased accessibility of job centres will contribute not only to the residential attractiveness of the affected places but, secondarily, it will account for agglomeration benefits in terms of the location of firms in the centres. This may influence the general pattern of job allocation within the country, with impacts on the amount, choice and overall accessibility of jobs outside the corridors of speeded infrastructure lines. In terms of the objectives of this article, which focus on alternatives to the rough comparisons of costs of alternative speed transportation infrastructures, this would enhance the differences among the options, and as such, it deserves another study.

Secondly, the GIS-based calculations of the model simplify the actual spatial conditions by concentrating the source places from which commuters start their journeys, as well as the destination centres, to single reference geographical points. Note, however, that the national scale of the assessment considers only benefit distribution at the regional scale, and this process will obviously not be affected by this simplification.

Thirdly, the model ignores possible congestion effects as it presumes that the new transportation lines will be dimensioned appropriately to the expected traffic loads. On the other hand, the experiences from already-completed transportation improvements by new motorways and city by-passes have shown that the increased capacity of the network would improve the congested segments of the pre-existing roads only temporarily. Additional demand results from the increased offer of transportation capacity after some time (e.g. Braess, 1968; Beck and Bliemer, 2015).

The use of the model based on a single / general distance decay curve and ignoring the time-distance relations within urban areas, is limited to the large scale of a whole country. On the other hand, the national borders cannot be considered as definite limits to the model, which would otherwise distort the outcomes of the model. Therefore, neighbouring centres in other countries were also accounted for, even if some factors relevant to cross-border commuting were not considered, e.g. legal and language barriers.

For more precise assessment of the benefits resulting from the construction of the speed connection rail lines, their potential competitiveness against air transport should also be considered. This would, however, require an analysis on a wider scale and with modified parameters, adequate to account for different uses by different users compared to job locations and everyday commuters.

Future research should focus on the study of the potential long-term impacts of the improved accessibility to large centres on their smaller competitors, namely on the possible deterioration of local services and facilities in the affected small centres, whose central functions will not be viable given the level of competition by major centres.

For further development of the assessment model, other segments of users should be incorporated into the assessment of benefits. Possibly their significance could be validated by triangulating the model with data on property price differentials among various places – before and after already executed motorway construction and upgrading rail projects.

7. Conclusions

The planned networks of transport infrastructure will improve the accessibility of jobs and services and, consequently, the attractiveness for living in most places in the Czech Republic. The benefits from improved accessibility, however, will not be evenly spread and there will remain areas that will not benefit at all. Thus, the increased attractiveness of the centres occasioned by their improved accessibility will reinforce the existing polarisation and divergent trends (cf. Maier and Franke, 2015), with consequent increases in inter-regional as well as intra-regional disparities.

Significant improvements will occur in the corridors of new motorways, as these projects serve the hitherto poorly accessible parts of the country, and they will improve accessibility in these parts. Since the total benefit derives from the population density and the centre comprehensive size of accessible centres, total benefit related to the investment costs will be smaller in the case of new motorways than the comparable benefits from the planned rail upgrades and new rail construction, which will serve more populated parts of the country and connect them with major centres.

Given these results, the upgrading of existing railway lines under current planning (level A) represents some start for making railways competitive with road transport. The next levels (B and C) of rail investments consist in constructing new speed connection rail lines. The speed connection routes that do not follow the corridors of upgraded rail lines would bring the greatest effects on accessibility and attractiveness for commuting. The improvement, however, will affect only that part of the country's population connected to the serviced centres. Intermediate stop overs servicing smaller centres along the speed connection lines and, concurrently improved parameters of the existing railways that follow-up on the lines, will intensify benefits from development of the speed connection lines.

The benefits from the new speed connection network that makes their construction costs feasible from the point of view of territorial benefits, indicate that the target speed on them should reach around 250 to 300 km.h^{-1}.

All the investigated alternative plans result in the concentration of the highest increase of attractiveness in two larger territories. The ultimate "winners" would be: first, the

wider metropolitan region of Prague, owing to the high value of Prague's "centre comprehensive size" (KV); and secondly, the 'core area' of Moravia, encompassing the city network of Brno, Olomouc, Ostrava and Zlín, by improved interaction between these regional centres, as well as multiple choices of accessing these centres from places between them.

Thus, this will further emphasise the distinction between the monocentric pattern of Bohemia, where the regional centres play the role of higher-rank satellites to Prague, and the polycentric pattern of the Moravia-Czech Silesia region, which lacks the equivalent of a single strong metropolis in its territory. The improved access to Prague from Moravian centres may even strengthen the dependency of the Moravian polycentric system on metropolitan Prague.

Knowledge of the regional and even the sub-regional importance of the speed transportation infrastructure in small countries like the Czech Republic can be useful to other countries of similar size that consider establishing and developing their national speed rail network. For larger countries like France, Spain and Poland, speed rail is or could be an alternative to air transportation. As well as small countries with high population densities and a high number of cross-border and international travels like Belgium and the Netherlands. Countries of the size of the Czech Republic, with mostly a national scale of passenger frequency, cannot rely on the efficiency of fast rail lines that would serve only two or three national centres. Therefore, small countries with mostly internal commuting mobility and relatively lower population density, should consider a combination of classical high-speed railways with branches serving smaller centres alongside the high-speed track.

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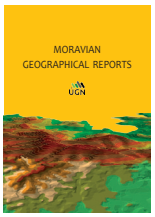

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Viticultural landscapes: Localised transformations over the past 150 years through an analysis of three case studies in Slovakia

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Abstract

The transformation of vineyard landscapes is evaluated in this article by assessing the changes in land cover and landscape diversity in selected study areas in two time periods – from 1867 to 1949, and from then to 2016. The study areas are characterised by a long history of viticulture and with important occurrences of old and new agrarian relief forms. Fine-scale land cover and landscape diversity analysis, as well as the study of historical and strategic documents, enabled an accurate interpretation of the viticultural landscape trajectories and their drivers. Landscape diversity was computed using the Shannon diversity index for each 625 square metre grid unit, and applying other metrics for the entire study area. Our research established that the study areas oscillated during this period between extensification and agricultural intensification, and the general trend confirmed the disappearance of traditional vineyards and a decline in modernised vineyard areas after socialism. Although extensification and intensification are seemingly contradictory processes, it is established that these both increase landscape diversity. In addition, landscape diversity changes in the second period are influenced more by changes in quantitative landscape pattern characteristics via edge density than qualitative patterns, e.g. patch richness, which reflect land use diversity.

Keywords: *vineyard transformation, vineyard terraces, land cover, landscape diversity, change drivers, Slovakia*

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1. Introduction

The viticultural landscape is one of the oldest types of cultural and cultivated landscapes in Europe and it creates a unique genius loci in many regions with its distinctive function and appearance. It also forms a special part of the agricultural landscape and has therefore been intensively studied. Examples include the following different contexts: the physical-geographical background (Biddoccu et al., 2016; Comino et al., 2017; Lieskovský and Kenderessy, 2014); economic efficiency (Costantini et al., 2016; González et al., 2017; Torquati et al., 2015); ecosystem services (Garcia et al., 2018; Winkler and Kimberly, 2016) and land cover (LC) changes (Greinert et al., 2019; Vinatier and González-Arnaiz, 2018).

Terraced vineyards are among the oldest examples of cultural landscapes in Europe and studies focused on these present important research (Haffke, 1994; Ramos and Porta, 1997; Rodrigo-Comino et al., 2019; Tarolli et al., 2014), especially the dry-stone terrace vineyards spread mainly throughout Mediterranean areas (Barbera and Motisi, 2017). Terraced viticulture in Central Europe was previously assumed to begin between the 10th and 14th centuries, but indirect archaeological and archival findings indicate its earlier occurrence around the 4th to 5th centuries (Petit et al., 2012). In addition, an overview study of terraced landscapes was performed by Wei et al. (2016), following Stanchi et al.'s (2012) recording of considerable traditional terraced agricultural systems in marginal, steeply sloping areas in the Alpine, Mediterranean and Sub-Mediterranean regions.

The wave of building and modernisation of the European Union (EU) vine-growing terraces, especially those in the Mediterranean, occurred in the 1980–1990s (Borselli et al., 2006; Cots-Folch et al., 2006). After 2000 this process was connected to the EU implementation of the Common Agricultural Policy (CAP – Commission Regulation EC

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No. 1227/2000 of 31 May 2000; Martínez-Casasnovas et al., 2010). The CAP subsidies strongly encouraged the establishment of large-scale vine-growing terraces. The establishment of large-scale vine-growing terraces, however, caused many environmental problems such as erosion, soil degradation, landslides and the disappearance of the traditional wine-growing landscape (Cots-Folch et al., 2006, 2009; Ramos et al., 2007).

Despite the lack of sufficient archaeological and archival data on Slovak traditional terraced vineyards, there is indirect evidence that the oldest systems of vineyard terraces in the Little Carpathians region may have had their origin in the Middle Ages, because this was already a prosperous vineyard region in the 14th century (Drábiková, 1989; Lukniš, 1977; Slavkovský, 2009; Špulerová et al., 2017). Mechanisation was not feasible, however, because of the divided plot structure, the amount of dry-stone terraces and the huge stone walls along the plot boundaries. Vine-growing modernisation in Slovakia, which aimed to counteract the shortcomings of traditional wine-making, began during the state-controlled intensification of agriculture under socialism. Vineyard transformation with construction of terraces compatible with mechanisation also occurred in the second half of the 20th century in other socialist countries, such as Hungary and Slovenia (Borselli et al., 2006; Momirski and Kladnik, 2009; Pipan and Kokajl, 2017).

Given this background, the main aim of this study is to evaluate vineyard landscape transformations by identifying and assessing the land cover (LC), landscape diversity (LDI) and related factors in the time period spanning the change from free market to socialist economies. This evaluation emphasises the transformation of the traditional landscape into the modern collectivised structure.

The first period of change covers the relative continuity in property relationships under market economy conditions, and the second period captures collectivisation under a directed centrally-managed socialist economy and subsequent changes due to its collapse.The modern wine-growing landscape is composed of large-block vineyards and vineyards on bench terraces. All the impacts on vineyard diversity from landscape collectivism, terrace construction and vineyard abandonment, however, have not yet been sufficiently developed.

In this research project, we assumed that:

- Assessment of the trajectories of changes in land cover and landscape diversity, which are characterised by a significant proportion of agrarian relief forms at a detailed scale, enables the identification of those landscape processes and features that cannot be realised by standard LC and LDI research methods and measures;
- Trends in parallel extensification and intensification, especially typical of European agricultural land in the 20th century, are evident in the study areas (van Vliet et al., 2015). In countries under socialist collectivism, these are conditioned by both global and specialised drivers;
- Extensification and abandonment exhibit similar intensity in both traditional landscapes and the large-scale vineyards created under collectivisation; and
- Increased diversity of the vine-growing landscape determines both extensification in its usage and intensification associated with vineyard terrace construction.

2. Data and methods

In this paper we have analysed the land cover and landscape diversity for three study areas at three different points in time:

1. The state of the study areas in the second half of the 19th century is identified in Selešťany (1867), Modra (1894) and Svätý Jur (1896). This depicts the effects of agricultural intensification, industrial development and overseas trade and transport. The Slovak territory at that time was part of the Austro-Hungarian Empire, and maps of stable cadastres in the original 1:2,880 scale were used in LC analysis;
2. The period after the Second World War and before socialist agricultural collectivism is reflected in the 1949 recorded landscape changes – in the late 19th century and the first half of the 20th. This was greatly influenced by the 1930's economic crisis, two World Wars, the collapse of the Austro-Hungarian Empire and the constitution of an independent Czechoslovakia. In this case, black-and-white aerial photographs from 1949 of the Historická ortofotomapa © GEODIS SLOVAKIA, s.r.o. a Historické LMS © Topografický ústav in Banská Bystrica, and the 1:5,000 1955 state map provided the substantive basis for our analysis. Period photographs and postcards were used as supporting documentation for some study areas for this year; and
3. Landscape analysis in Modra in 2015 and in Svätý Jur and Selešťany in 2016, established the current situation. This demonstrates the 1950–1980 landscape changes during socialist collectivism, the post-socialist restitution, the 1990–2000 agriculture transformation and the 2004 Slovak accession to the EU. The 2003 aerial orthophotos (Ortofotomapa © EUROSENSE s.r.o. a GEODIS SLOVAKIA) and rectified orthophotos from Google Earth 2016 Digital Globe, were verified by field research, and these provided the bases for our current land cover evaluation.

Hence, we evaluated the LC and LDI changes in the period between the chosen 19th century years and 1949 (1st period) and between 1949 and 2015/2016 (2nd period). The years for large-scale LC and LDI analysis were chosen in particular because of the availability of detailed and relatively reliable data. Additional monographs on the municipalities also offered relevant data on LC changes. (Antolov, 2007; Hodási, 2007; Turcsány, 2009; Žudel et al., 2006).

Details for the LC element classification were limited by source materials. In the second half of the 19th century this was due to the lack of aerial images, and the 1949 black-and-white aerial photographs have noticeably inferior quality compared to the current coloured orthophotos. We chose a minimal 15 m^2 mapping unit and 2 m minimal line-shape width to maintain consistent mapping detail for all three years, and the proposed LC classification was best adapted to conform to the 19th century stable cadastre maps, which had the least information content.

The complementary growth of fruit and vegetable crops was common in traditionally cultivated vineyards at that time (Agnoletti, 2015; Foški and Zavodnik, 2019), and the LC interpretation was therefore based on the 4th–6th hierarchy Corine Land Cover (CLC) levels sufficiently adapted to local characteristics and the diverse vineyard landscapes (see Appendix 1). We then implemented a detailed vineyard landscape classification system which could track landscape changes in the study periods. The identified vineyards

were subdivided into class 221 CLC vineyards and class 24 heterogeneous agricultural areas, where they are combined with crops in agricultural mosaics.

Class 221 was delimited in two distinct lower levels: large-block vineyards: internally homogeneous and over 5,000 m^2, and small-block narrow-stripped vineyards. The division of modern terraced vineyards into vineyards on bench terraces and into slopes of bench terraces is important in this context, because it makes the LC categories more precise in tracking land use changes and affecting the resultant LDI values and their changes over time. We then identified the typical agrarian stone walls and mounds of the traditional vineyard landscape as a distinct class.

The landscape changes were assessed by analysing LC element area changes over the studied periods. In this case, overlain GIS maps provided source material for LC assessment in the individual study areas and individual years, and the areal extent of changes in particular LC classes were compared in contingency tables. The LC changes were then classified according to the following modifications adapted from Feranec et al. (2010): 1) afforestation (A); 2) succession (S); 3) agricultural extensification (E); 4) de-urbanisation (D); 5) open woodland (WO); 6) deforestation (DE); 7) agricultural intensification (I); 8) urbanisation (U); 9) without change (W); and 10) other changes (O).

To understand the changes in the landscape, we analysed the driving forces that were influential processes in the evolutionary trajectory of the landscape and can be defined at spatial, temporal and institutional scales (Bürgi et al., 2004). We then identified natural, political, technological and economic drivers in the case study areas (Bürgi et al., 2004; Kanianska et al., 2014; Skokanová et al., 2016).

Our detailed scale of analysis, which was enabled by the use of grid units with an area of 25 × 25 m (625 m^2) is different to some other studies utilising square grids. We chose the size of the grid basic unit so that the smallest analysed LC polygon of the 4^{th}–6^{th} CLC hierarchical level would be smaller than the square size.

The Shannon diversity index (SHDI) from the Fragstat programme manual (McGarigal et al., 2012) was chosen for the assessment of the LDI state and changes. The acquired SHDI values were plotted as map colour-coding for the various LDI degrees, ranging from 0 for lack of diversity to a maximum of 5. Partial sets of SHDI > 0 values for individual study areas and individual periods were merged into one file. Five value intervals were assigned by the equal interval method from the value range of the merged file as LDI degree classes, and this covered all three study periods and all years. This enabled the comparison of the LDI values between individual study areas and periods.

We then evaluated the LDI value and intensity changes as SHDI value differences in individual years. The resultant SHDI value-difference files were divided by the 6 equal interval method, and squares with zero change were set separately. As previously, we considered the entire LDI changed value range from all study areas and both periods to construct the intervals. This enabled comparison between the individual study areas and periods. In addition to the SHDI calculation for the individual grid squares, metrics unable to be effectively analysed in the grid were calculated for the entire study area and then analysed. The selection and calculation of these metrics was based on the Fragstat manual (McGarigal et al., 2012):

1. SHDI index;
2. number of patch types per ha (PRha);
3. number of patches/ha (NPha); and
4. total edge length in m/ha (TEha).

The correlation coefficient (r) matrix enabled the detection of the relationships between selected metrics and especially between these and grid-based LDI values and the grid-averaged and overall SHDI values. The r-value signified strong correlation and this was established for our low number of data-sets at 0.91 with 99% confidence (n = 9: 3 study areas × 3 periods) (Pavlík and Kühnl, 1981). The intensity of change over a period was assessed by correlating SHDI values over the grid between the two years, bracketing the period. Higher r-values denote greater similarity in LDI value distribution and smaller LDI changes over the relevant period.

3. Study areas

The three case study areas are depicted in Figure 1. The 66.2 ha Svätý Jur and 87.8 ha Modra study areas have similar natural backgrounds and are situated north-east of Bratislava on the south-eastern slopes of the Little Carpathian mountains. The geological composition is dominated by granites, and altitudes vary from 144 to 333 m a.s.l. in Svätý Jur and 174 to 349 m in Modra. The Svätý Jur study area relief is slightly more dissected than Modra. There is no well-developed permanent river system and loamy-sand cambisoils are the prevalent soil cover, but this is converted to culti-soils by regular vineyard cultivation and terracing. The climate is moderately warm and dry, with mean annual temperatures above 9 °C and average annual precipitation between 550 and 600 mm. Only island residues of the original oak-hornbeam Carpathian forests, oak and Turkey-oak forest communities are still preserved.

These two areas are among the oldest vine-growing regions in Slovakia. The first mention of vineyards in the Little Carpathians dates back to the 13^{th} and 14^{th} centuries, and vine production underwent its greatest boom in the 16^{th} and 17^{th} centuries and it remained the most significant economic activity in this region by the end of 19^{th} and beginning of the 20^{th} centuries. The many old stone walls and mounds are now part of the cultural landscape heritage, and these agrarian landforms, sometimes up to 200 m long and 3 m high, originated over the centuries by removal of stones for land cultivation. They consist predominantly of granite debris, but they do not occur in Selešťany because of its different geological base.

In contrast, the 56.7 ha Selešťany study area is located in the Juhoslovenská Kotlina basin in south-central Slovakia on the Hungarian border, and the first records of vine-growing there come from the 14^{th} and 16^{th} centuries (Hodási, 2007). The altitudes of the currently terraced territory vary from 147 to 249 m a.s.l and there is no permanent river system. While the higher, less dissected parts of the study area are covered by eolic deluvial sediments, more resistant oligocene calcareous clastic sediments prevail on the steeper slopes along the northern and southern peripheries. The original soil cover has been transformed from pararendzinas and brown soils to culti-soils, and there are no remnants of the original vegetation cover or oak-hornbeam and Turkey oak forests. The study area is situated in a warm, dry region with a moderate winter and average annual precipitation between 550 and 570 mm.

4. Results

4.1 Land cover changes

We analysed the land cover in the study areas and the changes over time using CLC 3rd level classes (Fig. 2). This provided a reliable basic overview of the transformations.

Vineyards were a dominant element in all three study areas in the 19th century (Fig. 2). Although the largest proportion of vineyards was in Selešťany, over 50% of the Svätý Jur area also had cultivated vineyards. The 4th–6th CLC hierarchical levels reveal that small-block staked vineyards predominated in Svatý Jur and Selešťany, while Modra had small block staked vineyards on stone-walled terraces.

By 1949, however, the proportion of vineyards in Selešťany plunged from 82% to 8%, and 38% of the total area had complex cultivation patterns as the dominant land cover type. The decrease in the vineyard area in Svätý Jur was more moderate at that time, and grapevines remained the prevailing land cover type. In direct contrast, the Modra vineyard area increased from 33% to 49% in the studied area. In addition, the the remarkable 19th century historical area of agrarian stone walls and mounds which covered 6–8% of Modra and Svätý Jur had not significantly changed by 1949.

One notes that by 2015 in Modra and 2016 in Selešťany and Svätý Jur, there were marked study area changes in both landscape structure and its dominant features. Viticultural dominance had ended in Modra and Svätý Jur, and pastures filled 17% of the Svätý Jur total area, while non-forest wood-species vegetation took up 27% of the Modra area. In direct contrast, vineyards regained dominance in Selešťany, with 74% of the total area. The 4th–6th CLC hierarchical levels reveal that small block staked vineyards disappeared in all study areas and only their small fragments remained

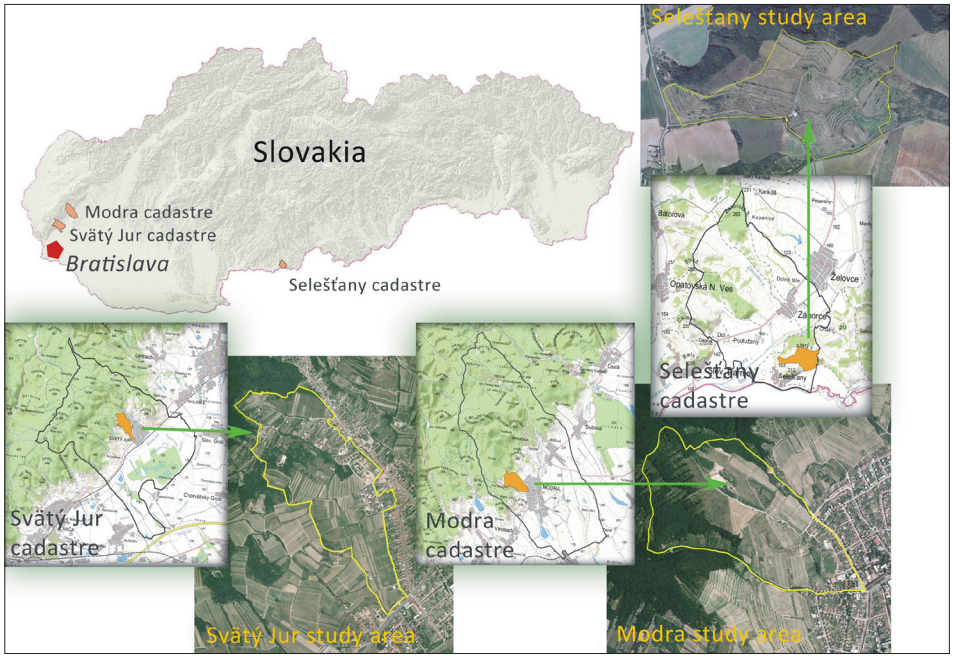

Fig. 1: Location of case study areas in Slovakia. Source: authors' elaboration

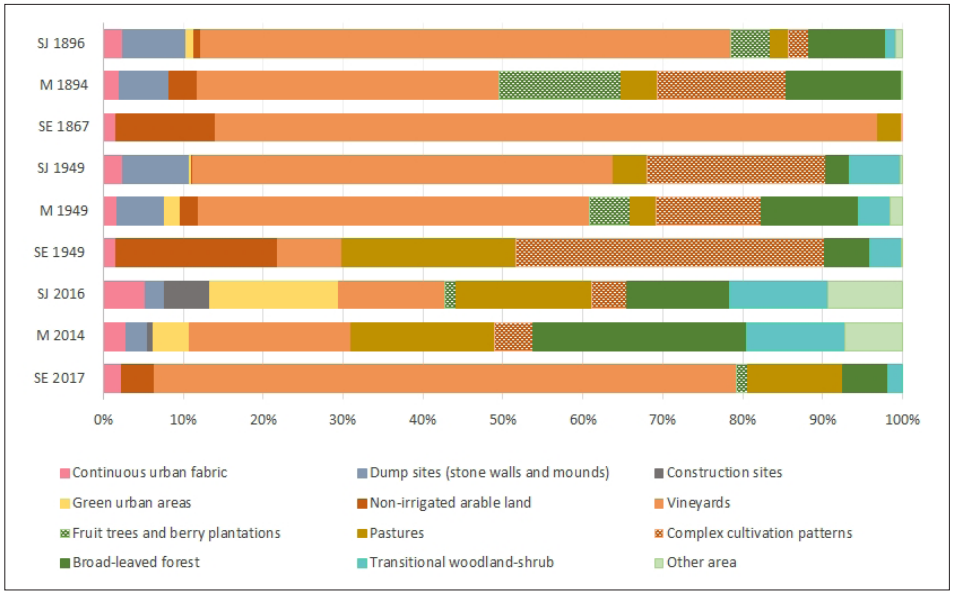

Fig. 2: Land cover at the 3rd hierarchic level in the study years. Classes under 5% of the study areas are grouped under "other area"; SJ = Svätý Jur study area; M = Modra study area; SE = Selešťany study area
Source: authors' computations

within complex cultivation patterns in the Svätý Jur and Modra study areas. Modern terraced vineyards, which in the collectivist era covered 15% of Modra, 20% of Svätý Jur and 56% of the Selešťany study area, decreased in 2015–2016 to 4% in Modra and Svätý Jur and only slightly to 51% in Selešťany. Similarly, the area of modern non-terraced vineyards went down from 34% to 14% in Modra, from 12% to 2% in Svätý Jur. In the Selešťany study area there was only a negligible decrease of them.

Traditional agrarian stone walls and mounds decreased significantly to 2–3% in the Modra and Svätý Jur study areas. Vineyard bench terraces had appeared as a new agrarian land form in all study areas under collectivism, with 12% of the total Modra area, 21% of Svätý Jur and 50% of the Selešťany case study area.

4.2 Types of landscape changes

The comparison of 4th–6th hierarchical level LC in all studied years identified the types of landscape changes in both study periods (see Tab. 1), with 57% of the Modra territory and 64% of Svätý Jur remaining unchanged during the first study period. The most significant change was the 19% agricultural extensification in Svatý Jur and 22% intensification in Modra, while Selešťany experienced extensification as the most significant change with over 62% of its territory.

In the second study period, substantially smaller study areas remained unaltered, with only 23% changed in Modra and 14% in Svätý Jur. There were two opposing processes, with 20% agricultural extensification in Modra and 24% in Svätý Jur, and 21% intensification in Modra and 23% in Svätý Jur. Urbanisation became more significant in Svätý Jur, with a 0% to 13% increase. In this period, Selešťany experienced agriculture intensification on 64% of its territory, together with 20% extensification and 25% succession.

Parts of the large-scale terraced and non-terraced vineyards again transformed into grassland, complex cultivation patterns and shrubs after socialism, resulting from extensification of agriculture and succession. This was most evident in the terraced vineyards, with 11% in Svätý Jur and 30% in Selešťany. In contrast, there was an 8% transformation of non-terraced vineyards in Modra, and up to 7% of large block terraced vineyards in Svätý Jur were affected by urbanisation.

4.3 Driving forces of change

The phylloxera epidemic in the second half of the 19th century was the major natural driver of vineyard decreases throughout Europe (Poláček and Poláček, 2010). Concurrently, political drivers strongly influenced viticultural development between the mid-19th century and the first half of the 20th century. These included land

Type of change (%)	A	S	E	DU	W	WO	D	I	U	O
SJ 1896–1949	0.1	3.8	**18.6**	0.0	**64.5**	1.6	5.5	**4.8**	0.3	0.6
M 1894–1949	0.8	2.8	**12.0**	0.0	**57.2**	1.1	2.5	**22.2**	0.8	0.1
SE 1867–1949	5.7	3.9	**62.4**	0.0	**10.0**	0.0	0.0	**17.9**	0.0	0.0
SJ 1949–2016	11.9	9.9	**27.2**	0.1	**13.7**	0.1	2.2	**19.2**	13.7	1.2
M 1949–2015	15.2	13.7	**20.3**	0.2	**23.1**	0.0	2.0	**20.9**	4.6	0.2
SE 1949–2016	3.5	**25.2**	**19.7**	0.0	7.5	0.5	5.2	**37.8**	0.5	0.0

Tab. 1: Types of study area changes in the two periods: A – afforestation; S – succession; E – extensification of agriculture; DU – de-urbanisation; WO – woodland opening; W – without changes; D – deforestation; I – intensification of agriculture; U – urbanisation (Note: the most significant changes above 10% of the study area are in bold); SJ = Svätý Jur study area, M = Modra study area , SE = Selešťany study area
Source: authors' calculations

reforms and land ownership changes before and after the collapse of the Austro-Hungarian Empire, and the intervening wars reduced the labour market. In addition to political factors, economic and technological drivers also acted here, such as the growing labour shortage notably due to increased industry and the decline in the demand for grape vines from increasing foreign competition, the economic crisis and also an increase in beer consumption (Demo et al., 2001).

The persistence of the Modra and Svätý Jur vineyards in the first period may well have been linked to strong political and economic drivers at the national level, because the state supported vineyard renewal through tax relief and free vine grafts resistant to phylloxera (Burdová, 2012). The wealthy vineyard owners made excellent use of these opportunities and the Svätý Jur and Modra municipalities, which were economically dependent on grape and wine production, had a strategic advantage due to their proximity to Bratislava, because this was the centre of the Slovak economy and the most important commercial outlet. In contrast, Selešťany was in a region where grape vines were not the only crop which supported farmers' material dependence (Drábiková, 1989). Therefore, wine growing preservation there was difficult in this financial situation, and this was further exacerbated by political drivers including the erection of bulwarks on the Czechoslovak-Hungarian border in 1937 and the surrender of this territory to Horthy's Hungary in 1938–1945 (Antolov, 2007).

Socialist collectivism proved to be the common technological driver for LC changes in all three study areas in the second period. The extensive terrace construction in the 1960s and 1970s required conversion of relief and soils, and this was compounded by typical abandonment of traditional Svätý Jur and Modra vineyards situated in higher and more difficult cultivation sites. Farmers were forced to join socialist agricultural cooperatives and they found working with machinery in large-scale vineyards easier than the heavy manual labour in traditional vineyards. A further political driving force for the decrease in traditional vineyard areas was the transfer of the German population after the Second World War, and many of these were experienced wine growers. In addition to technological and political factors, the natural drivers related to vineyard availability and location also played a role.

Further significant changes in the vineyard landscape after 1989 were caused by vineyard abandonment in the Svätý Jur and Modra study areas and their partial transformation into built-up areas. The major causes here were the political drivers such as withdrawal of socialist agricultural subsidies, the consequent attenuation of vine-growing in cooperative farms and land restitution. The increased developer pressure for high-density housing on the lucrative plots also played a role in the significant economic factors of land cover change. There have been signs of wine-growing revival in the last 5 to 10 years, however, especially in the Selešťany study area.

The current differences in vineyard management and the overall intensity of land use in the study areas are reflected in the rate of utilisation of agri-environmental subsidies. While subsidies are drawn on 81% of the Selešťany study area, this is reduced to 3–4% of the Svätý Jur and Modra areas (LPIS, 2016). This temporary political driver therefore affects the case study areas to differing degrees. Farm structure and size is a further local technology driver, which suggests a potential for preserving viticulture in the study areas. While socialist cooperatives ceased to exist in Svätý Jur, where there are now 26 individual vinegrowers, they continue in Modra where one cooperative is the second largest employer in the town, competing with 35 individual vinegrowers. These study areas are distinctly different to Seleštany, where a single vinegrower manages all vineyards in this study area.

4.4 Landscape diversity and its spatial and temporal variation

Table 2 highlights the LDI values initially calculated as the square grid average for individual study areas and their changes over the selected years. There is an obvious trend in LDI increase over the considered years and decreased territory with zero diversity, thus signifying relatively complete homogeneity in Svätý Jur and Selešťany. In contrast, the trends are less clear in Modra, which has a slight increase in zero-diversity territory.

Table 2 also presents the selected metrics for individual study areas as a whole, without the use of the square grid for the considered years. A comparision of the results for both metrics groups reveals that the individual landscape metrics do not always provide the same, or even vaguely similar, variation over time. The SHDI values are calculated as an average of the values for individual grid squares and those for the study area as a whole. Although these mostly change in the same manner, discrepancies exist between the first period in Modra and the second period in Selešťany. These differences result from the dissimilar scale of SHDI value assessments, where our 625 m^2 squares overcome problems created in study areas dozens of hectares in size. Transformation of the Selešťany study area into modern vineyards in the 2nd period proves interesting, because SHDI and PRha decreased while NPha, TEha and MPS increased. This is related to the predominant use of the Selešťany study area for vine-growing on modern terraces.

Study area/year	LDI assessment in the grid		LDI assesment in the whole territory of study area				
	Zero SHDI (% of study area)	Mean SHDI calculated from grid	SHDI	PRha	NPha	MPS (ha)	TEha (m)
SJ 1896	32.2	0.174	0.801	0.27	2.92	0.34	483
SJ 1949	26.1	0.196	0.943	0.24	2.86	0.35	509
SJ 2016	18.7	0.244	1.187	0.33	4.47	0.22	692
M 1894	24.2	0.198	0.900	0.14	2.68	0.37	479
M 1949	25.1	0.196	1.035	0.27	2.69	0.37	470
M 2015	26.6	0.219	1.208	0.48	4.48	0.22	632
SE 1867	58.8	0.080	0.493	0.16	0.74	1.35	197
SE 1949	30.1	0.176	1.003	0.30	2.38	0.42	408
SE 2016	16.1	0.262	0.815	0.23	4.56	0.22	876

Tab. 2: Chosen LDI metrics from a) grid, and b) whole territory. Chosen landscape metrics for the whole study area: SHDI – Shannon diversity index; PRha – number of patch types per ha; NPha – number of patches per ha; MPS – mean patch size; TEha – total edge per ha; SJ – Svätý Jur, M – Modra, SE – Selešťany study area
Source: authors' calculations

	Sum of 4th and 5th category of LDI (% area)	Average SHDI (grid)	NPha	MPS (ha)	PRha	TEha	SHDI (whole area)
Sum of 4th and 5th category of LDI (% area)		**0.971**	**0.959**	**– 0.910**	0.516	**0.910**	0.768
Average SHDI (grid)			**0.938**	**– 0.910**	0.410	**0.947**	0.697
NPha				– 0.839	0.613	**0.947**	0.704
MPS (ha)					– 0.496	– 0.779	– 0.784
PRha						0.736	0.758
TEha							0.030
SHDI (whole area)							

Tab. 3. Matrix of correlations between selected LDI metrics (abbreviations as in Tab. 2). The values with significant correlation are in bold (r ≥ 0.9). Source: authors' calculations

Table 3 presents a correlation analysis between the following selected metrics:

- the PRha parameter defines the patch richness per hectare, and here it equals the number of LC types per hectare, while the SHDI metrics are based on the number of LC types. PRha, however, has no significant relationship with the SHDI value either over the grid-based average or overall for the entire study area;
- in contrast, the average SHDI value of the grid squares increases with increasing areas with high 4th and 5th LDI degrees. The NPha and TEha metrics concomitantly increase and the average patch size (MPS ha) decreases.

The above correlations show that the changes in landscape diversity were more affected by changes in quantitative landscape characteristics rather than the qualitative characteristics which reflect land use diversity.

The map in Figure 3 highlights the changes in land diversity (LDI) in both periods.

Although LDI in the Svätý Jur study area in 1949 had increased compared to 1896, over 56% of the extent of the study area underwent no LDI change, especially in the central part. Furthermore, changes in the LDI distribution during the 2nd period were mainly caused by vineyard terracing and housing extension.

The highest LDI changes in the Modra study area in the 1st period are concentrated along the north-eastern edge of the study area, but in the 2nd period they are confirmed in the central part, at the boundary of the hillly land and mountains, and also in the southern part of the study area where urban housing has increased. In contrast to Svätý Jur, the Modra LDI increase in the second period was not induced by the construction of terraced vineyards but mostly by increased housing adjacent to the urban area. Another typically distinct form of LDI growth was identified in the higher and more dissected study area locations where spaces between stone mounds, covered originally by the traditional staked vineyards, were extensified to diversified mosaics of non-forest woody vegetation and overgrown meadows and pastures.

The most extreme LDI changes, however, occurred in the Selešťany study area, where the distribution of LDI values varied significantly in each considered year. The fraction of the territory with high 4th and 5th SHDI degree LDI increased here from 2% in 1867 to 26% in 2016. In addition, almost 60% of the study area was homogeneous in 1867, with the highest homogeneity of the three study areas, but this decreased to the lowest of the three study area values at 16%. These changes show the intensity of Selešťany transformation, distinguished by high variability in LC types and consequent high LDI.

Areas with the higher 4th and 5th SHDI degree LDI increased significantly in all study areas and covered higher proportions of the total areas in 2015/2016 than in the 19th century. In addition, the extent of areas with zero LDI in the Svätý Jur and Selešťany study areas experienced downward trends in both periods, while Modra registered no significant change.

5. Discussion

5.1 Methods

The analysis of LC and LDI changes is a standard tool in evaluating landscape structure, and it is therefore used in many studies. For this study, however, we added detailed LC/LU mapping to obtain dynamic landscape information at the local level. The proposals for nomenclature of Corine Land Cover (CLC) mapping on 1:10,000 and 1:50,000 large scales were published by Feranec and Oťaheľ (1999) and Kopecká (2006). The proposed CLC classifications can be supplemented and further subdivided depending on the purpose of the evaluation, so we adapted it to the specific local features of distinct proportions of vineyard landscape relief forms. Detailed LC analysis from aerial images and

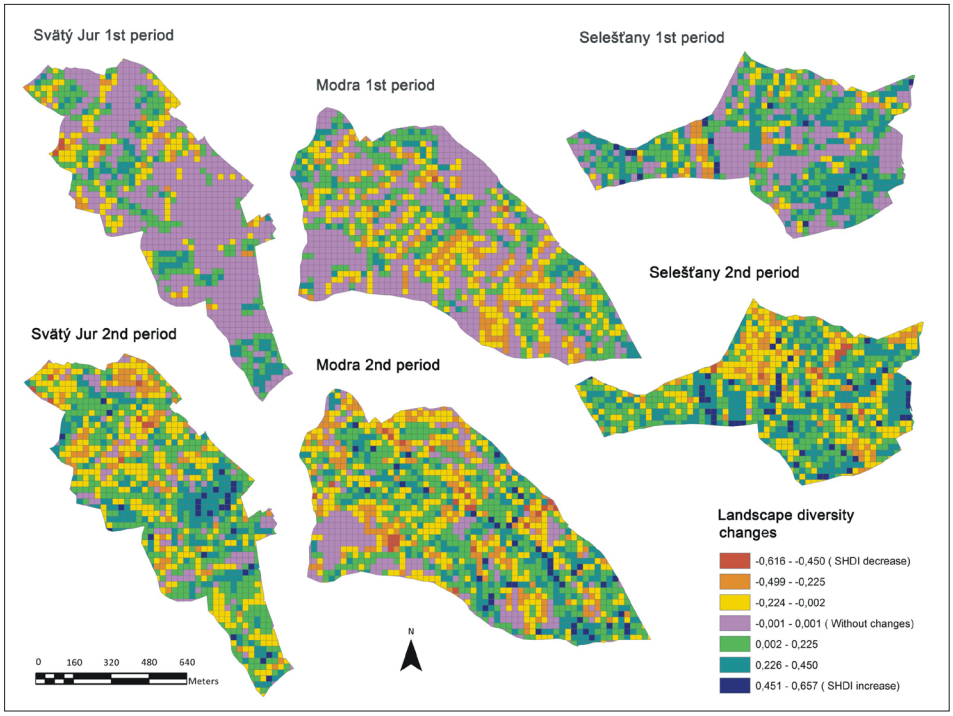

Fig. 3: Landscape diversity changes in individual study areas over the two periods (1st period – between the chosen 19th century years and 1949: 2nd period – between 1949 and 2015/2016)
Source: authors' calculations and map elaboration

historical cadastral maps then enabled identification of old man-made structures (Hamre et al., 2007) and diverse land-use forms which are generally mapped on a broader scale in one LC class type. The cadastral maps are the most important historical map sources, compared for example to Military Survey maps, because of their accuracy and large 1:2,880 scale (Bruna and Křováková, 2006; Domaas et al., 2007).

The 1989–1990 end of the socialist period led to major political and economic changes, and the lack of data for this period distorts our evaluation of LC and LDI changes to some extent. The second 1949 to 2000s period covers both socialist and post-socialist eras and these have very different trends. Disentangling these, however, presents a topic for further research.

The emergence of modernised vineyards during collectivisation had a significant effect on landscape changes in the second observed period. Many vineyards were abandoned after the fall of socialism and their original area remains unknown; therefore we created a map layer documenting the extent of large-scale terraced and non-terraced vineyards created during this period. These data enabled relatively accurate analysis of the extent and nature of the changes. We then analysed additional data sources, including historical archive records and historical monographs, to ascertain how the traditional vineyard landscape looked, and then to identify the driving forces for its change. This aggregation of data and maps is a common method of researching fine-structured traditional landscapes (Cullotta and Barbera, 2011; Ellis et al., 2009; Kizos et al., 2010; Špulerová, et al., 2011).

Analysis of the LC and LDI changes was based on the large LC map, and multiple landscape metric types were used for LDI calculations. These ranged from the simple patch richness index to the more complex Shannon diversity index (SHDI) and Simpson diversity index (SIDI) (Oťaheľ et al., 2004; Ramezani and Holm, 2011; Velázquez et al., 2019). Although we did not find precise fine scale studies to assess the landscape diversity of terraced areas, the studies by Agnolleti et al. (2015) and Kladnik et al. (2016) were the closest to our research topic. Agnoletti et al. (2015) used the terracing intensity index combined with a land use database to study the quantitative distribution of terraced landscapes on a regional level. Kladnik et al. (2016) then evaluated the diversity of both traditional and new terraced landscapes in pilot settlements using various landscape indices, including patch richness (PR), SHDI and the Shannon evenness index (SHEI).

The calculation of LDI on a regular grid of squares or hexagons provides additional information on the spatial distribution of LDI values in the landscape (Boltižiar, 2007; Halada et al., 2011; Oťaheľ et al., 2002, 2004; Plexida et al., 2014). In addition, our method enables the temporal and spatial comparison of LDI values expressed by SHDI values. These data acquired from a 25×25 m grid of squares, are therefore sufficiently detailed for use in practical landscape management.

While, a possible deficiency in this method may be that interpretation of some additional LDI metrics is limited by the small area of the grid square and the relatively small edge length, Boltižiar (2007) applied 50×50 m and 100×100 m square grid sizes and has supported our results by suggesting that "using a smaller square size somewhat eliminates the impact of minimum area classes on LDI calculation". Further, Plexidaa et al. (2014) also recommended adapting the extent of the landscape grid to the LC mapping scale.

5.2 Major trends in our study areas compared to other European vineyard landscapes

The first study period established no clear developmental trends in changes or agricutural extensification, and LC changes assessed by fine-scale mapping correlated with the changing trends in vineyard landscapes published for both regional areas and Europe. A diminished traditional staked-vineyard area is evident in the first period in the Svätý Jur and Selešťany study areas, and a decreasing vineyard area trend has also been noted between 1880 and 1950 in the Czech Eastern Moravian area (Skokanová et al., 2009) and also in Catalonia and Tuscany (Olarieta et al., 2008; Agnoletti, 2007). In contrast, the increased vineyard area in this period in Modra is thought-provoking, but it is most likely that the local vine-growers were more experienced in using the available institutional and economic tools to their advantage.

The second period revealed a marked decrease in vineyard extent in Svätý Jur and Modra, and we also identified a similar decrease throughout Slovakia from 15,250 ha in 1945 (Demo et al., 2001) to 10,500 ha in 2017 (Štatistická ročenka Slovenskej republiky, 2016). The Slovak decrease must be taken in context, however, with a significant 30,840 ha increase in vineyard area during socialism, (Demo et al., 2001) and the following post-socialist decline. Studies in the Czech Republic also confirmed this trend (Demek et al., 2007; Demek et al., 2008; Skokanová et al., 2009; Havlíček et al., 2009; Havlíček et al., 2011). The major reasons for the marked decrease in the extent of the Modra and Svätý Jur vineyards were their profitable location close to Bratislava, with a significant demand for building lots, and the attitudes of new owners after land restitution, competing with wine-makers who wanted to rent or buy the lots for vineyard use (Krnáčová and Štefunková, 2011; Štefunková et al., 2011; Lieskovský et al., 2013).

The land restitution and loss of production subsidies to cooperative farms after socialism caused extensification and the abandonment of the agricultural landscapes of post-socialist countries (Kuemmerle et al., 2016; van Vliet et al., 2015), and this especially affected the vineyards. The continuity of small family farms had been severely interrupted following the transfer of the autochthonous German population (Skokanová and Eremiášová, 2012) and collectivism (Cambel, 2005). This contrasted sharply with traditional vine-growing areas in Western and Southern Europe, where farms were gradually structured according to their size, ownership and the preservation of traditional practices (Caraveli, 2000; Cots-Folch et al., 2009). The development of contemporary family vineyards originated mostly after 1990 in the Svätý Jur and Modra study areas, but this is strongly limited by the pressure of investors and the interests of landowners to sell the land for construction purposes.

Although we did not establish the precise percentage of vineyards in individual farms, we confirmed many small farms in Svätý Jur and Modra and only one vine-grower managing land in the Selešťany study area.

Large block vineyards originated in Slovakia during socialism, followed by abandonment in the transition period (Lieskovský et al., 2013), and finally the greatest change in

vineyard use between 1990 and 2006 was to ploughed fields. This was largely due to the more favourable and profitable subsidies for arable land than vineyard cultivation after Slovakia's 2004 accession to the EU. Further, Špulerová et al. (2017) recorded that abandonment was most pronounced in the large block terraced vineyards.

The 1990s saw the commencement of Western Europe's massive support for the EU CAP, and this caused intensification and increased cropland area (Kuemmerle et al., 2016). This included vineyards, and especially those on the hilly slopes of Mediterranean areas (Cots-Folch et al., 2006; Ramos et al., 2007). Heavy land levelling and terracing was reinforced there by the EU subsidy policies (Cots-Folch et al., 2008), and the massive financial support for viticultural development in the EU parallels the modernisation of Central and Eastern European vineyards in the socialist era.

Extensification and the abandonment of traditional vineyards in our study areas occurred simultaneously with the modernised vineyard intensification and subsequent abandonment in the second half of the 20th and beginning of the 21st centuries. This abandonment of traditional vine-growing areas in the second half of the 20th century was also common in other Slovak and European wine regions (Agnoletti, 2015; Incze and Novák, 2016; Lieskovský et al., 2015; Petanidou et al., 2008). The driving factors here were agricultural industrialisation, labour loss to cities and extensive urban development (Olarieta et al., 2008; Tarrolli et al., 2014).

The abandonment of terraced areas farthest from villages, especially in the Central Pyrenees and the Iberian Range, and on land that was either marginal or hard to mechanise, has been documented by several authors: Arnáez et al. (2011); Cots Folch et al., (2006); García-Ruiz et al. (1996); and Lasanta (1988). Momirski and Kladnik (2009) have reported greater grass overgrowth and afforestation on Slovenian traditional terraces than on non-terraced land. These studies support our finding of the greater abandonment of traditional terraced vineyards than non-terraced grape-growing areas, and we further confirmed slightly higher abandonment of large-block terraced vineyards than large-block non-terraced vineyards, as reported throughout Slovakia (Špulerová et al., 2017). Greater physical work and financial inputs have always been required in terraces than in non-terraced areas and this continues today. Thus, despite the benefits of greater sunlight, better microclimates, erosion prevention and current subsidies for vines on terraces, this viticultural method remains unprofitable. Further, Kladnik et al. (2016) record that although terraced vineyards are aesthetically appealing, wine-growers are now trying to increase grape yield, even at the expense of lower quality, by conversion to vertical plantations with their inherent increased landslide risk (Pipan and Kokalj, 2017).

Climate warming and the increasing northern vine cultivation boundary, could slow down vineyard abandonment or even stop it through future use of Slovak grape varieties, which remain uncultivated because of the colder climate. Matese and Di Gennaro (2015) have also claimed that it will be necessary to introduce more extensive systems of precision viticulture to eliminate damage from new, unknown diseases and pests, sudden climatic extremes and droughts that threaten grape-vines. It would be very beneficial to consider introducing irrigation in the driest areas, but this is an uncommon practice in Slovakia.

The LDI values in our case study areas had mostly an upward trend in the three considered years, but in the intervening periods most likely experienced wide fluctuations. While NPha and TEha values increased and MPS decreased, no major correlation was established between PRha and SHDI, either as a grid square average or overall. It is therefore possible that landscape diversity is increasing because of landscape fragmentation rather than greater heterogeneity in land use. In support, an increase in LDI expressed by SHDI with increasing landscape fragmentation, has been confirmed by other authors, including Carranza et al. (2007) and Forman and Godron (1986).

The construction of modern terraced vineyards and merging small-area vineyards into larger blocks affected LDI in opposing directions. The terrace construction enhanced relief dissection and landscape diversity, but the merged small-area vineyards and stone mounds removal in the study areas of Svätý Jur and Modra contributed to LDI reduction. In these areas, however, terrace construction had such a range and intensity that it resulted in an overall LDI increase despite the processes decreasing LDI. The latter included the dense pattern of terrace platforms with vine plants combined with terrace slopes with shrubby and grass-herbal vegetation, which significantly fragmented large parts of these areas. Although the heterogeneity of land utilisation was reduced here, the dense structure of semi-natural habitats on terraced slopes created the potential for increased biodiversity, as reported in Košulič et al. (2014).

In comparison, in the Selešťany study area the LDI values changed more in the 1st period than in the 2nd period under collectivism. This highlights the finding that the process of vineyard landscape extensification can, in some cases, lead to higher LDI increase than terrace construction under collectivism. Further, the spatial changes in LDI values are mostly unrelated to particular natural conditions, but determined by external economic and social impacts which altered the landscape structure and patch type. Therefore, a comparison of LDI changes with other territories would require precise knowledge of vineyard landscape processes under collectivism, but appropriate studies on this topic are not available.

The changes in LDI expressed by the SHDI relationship with changes in landscape metrics are also ambiguous. For example, we recorded increased NPha values in the Svätý Jur area during the 2nd period and a concurrent SHDI increase, but despite the consensus that increased SHDI is associated with increased NPha, Selešťany had increased NPha but decreased SHDI in this period. This is supported by Arnaez et al.'s (2011) similar findings of SHDI increase and NPha decrease.

Kladnik et al. (2016) also found that "mono-tonal" areas with extensive modernised terraced vineyards have low LDI, and this is in direct contrast to our findings. In this context, the importance of the definition of the "terraced vineyard" category requires consideration. While the above-quoted authors used the system of bench terraces and bench terrace slopes in the terraced vineyard to convey one integrated LC type, we considered that bench terraces and their slopes comprise two different LC types. Our reasoning is based on the fact that bench terraces and bench terrace slopes are functionally contrasted units, including possessing differences in slope, amounts of energy received and maintained and distinct biotopes. Although distinguishing

these types increases patch type number by only one type, the increase in edge length between terraces and slopes significantly increases the LDI value.

More recently, Foški and Zavodnik (2019) examined changes in selected landscape metrics using similar methods to those herein with stable cadastres and current land records. They analysed detailed landscape diversity changes on five sites in municipal cadastres in the Slovenian Alps and reported that the number of patches, patch richness and Simpson diversity index increased in almost all territories, including Vinolje, which focused on viticuture. The comparison of our results from 1867–2016 highlights the increase in landscape diversity metrics as well.

Analysis of the reported LDI changes also highlights ambiguities in the interpretation of the LDI values and their changes. This is especially obvious in conclusions drawn from LDI changes in collectivised agricultural landscapes. The results and their interpretation there depend on both the specific natural, social and economic characteristics of the studied area and on the methodology used. This ambiguity is indirectly confirmed by Nagendra (2002), who established differences in the order of LDI values measured by SHDI and the Simpson diversity index (SIDI) on a set of 13 territories.

6. Conclusions

In this paper we have analysed trends in LC and LDI changes in vineyard landscapes which have a high proportion of agrarian relief forms, especially terraced vineyards. The research was based on an examination of three selected study areas during two periods, and the LC changes determined by fine scale mapping generally correlated with trends published for regional and European vineyard landscapes.

We confirmed results from previous small-scale studies from Europe that the vine-growing landscape in our study areas in the second half of the 19th century and its further development over 150 years, oscillated between viticultural extensification with abandonment and strong intensification. In addition, the general trend also identifies the slow disappearance of traditional vineyards and the decreased area of modernised socialist era vineyards. Our research has also established that the parallel landscape phenomena of intensification and extensification (and abandonment) determine and confirm that the general trend of shifting vineyards from higher altitudes and slopes to flatter areas, provides greater vine cultivation efficiency and increased yields. This process in Slovakia was introduced during the agricultural collectivisation. Our further research results revealed that the LDI changes are due to combined changes in the qualitative and quantitative characteristics of individual landscape patterns. Moreover, the major milestones of LC changes herein determined the LDI changes, and these were due to socialist collectivism in the 1960s and 1970s and the decline in viticulture and vineyard abandonment after 1989.

Our initial expectations of relatively small LDI changes in the 1st period as a result of stable ownership relationships, and an increase in LDI following the construction of new terraced vineyards during collectivism in the 2nd period, have been generally confirmed. It has also been shown that the apparently contradictory processes of extensification and intensification of agriculture can both increase LDI, and these processes are particulaly apparent in the Selešťany study area.

The precise settings used in landscape terracing have a significant impact on resultant LDI values. The values determined in other studies, which consider the entire terraced vineyard as one unit, are significantly lower than our LDI values, where the terraced and sloped portions are treated as two separate identities with different energy and biodiversity components. These components increase the fragmentation rate expressed by edge density and SHDI.

In conclusion, our detailed evaluation of the spatial changes of LDI using a square grid and analysing the historical and current driving forces for development, established that local driving forces modify the effects of global driving forces, and also that the intensity of these forces varies considerably throughout the study areas. This was especially apparent in the significantly different development trajectories in the Svätý Jur and Modra study areas compared to Selešťany.

Finally, the ambiguous results from this study and comparable research are dependent on different landscape structure interpretation and consequent methodology. These factors highlight the necessity for a consistent approach to LDI analysis in any study territories.

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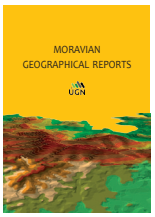
LC code 3rd level of CLC	LC code 4th–6th level of CLC	LC class	LC code 3rd level of CLC	LC code 4th–6th level of CLC	LC class
111	1112	polyfunctional areas in continuous urban fabric	221	221112	wire vineyards on stone-walled terraces
	1113	continuous urban fabric – family houses		221114	wire vineyards on bench terraces
112	1121	administrative areas in discontinuous urban fabric		221122	slopes of bench terraces
	1122	polyfunctional areas in discontinuous urban fabric		221211	small block staked vineyards (non-terraced)
	1123	discontinuous urban fabric – apartment houses		221212	small-block wire vineyards (non-terraced)
	1124	discontinuous urban fabric - family houses		221221	large-block staked vineyards (non-terraced)
	1125	scattered houses (out of settlement)		221222	large block wire vineyards (non-terraced)
121	1211	production halls, industrial parks, logistics centers	222	2221	extensive fruit orchards and chestnut groves
	1215	objects of hydrological infrastructure	231	2311	grasslands without woody vegetation
	1217	stables and other objects of livestock production		2312	grasslands with woody vegetation (the latter under 20% cover)
	1218	open air parking and storage places in agricultural farms	241	2411	annual crops and vineyards
	1219	storage places and barns in agricultural farms		2412	annual crops and orchards
122	1221	road network in settlement	242	2421	annual crops, grasslands and vineyards
	1222	access roads to agricultural land		2422	annual crops, grasslands, orchards and vineyards
	1223	other reinforced surfaces and squares		2424	annual crops, orchards and vineyards
131	1311	stone pits		2425	annual crops, orchards, vineyards and fruit shrubs
	1312	gravel pits		2426	grasslands and vineyards
132	1322	agrarian stone walls and mounds (kamenice)		2427	grasslands and orchards
133	1331	areas under construction		2428	grasslands, orchards and vineyards
141	1411	parks		2429	orchards and vineyards
	1412	woody vegetation lines, alleys	243	2431	grasslands and vineyards (20–40% woody vegetation cover)
	1414	home gardens		2432	orchards and vineyards (20–40% woody vegetation cover)
142	1421	sport facilities with predominantly grassy surfaces		2434	grasslands, orchards and vineyards (20–40% woody vegetation cover)
	1423	cottages and huts areas		2435	grasslands and orchards (20–40% woody vegetation cover)
	1424	swimming pools	311	3111	broad-leaved forests
	1425	other sport facilities		3113	non-forest woody vegetation
211	2111	large-block fields (above 5,000 m^2)	324	3241	transitional woodland-shrub (shrub succession under 40%)
	2112	small-block fields (under 5,000 m^2)		3242	transitional woodland-shrub (shrub succession under 80%)
221	221111	staked vineyards on stone-walled terraces		3245	forest nurseries

Appendix 1: Land cover classification of study areas at the 3rd and 4th–6th level of CLC mapping



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Assessing environmental fragility in a mining area for specific spatial planning purposes

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Abstract

Environmental fragility in a mining area is evaluated both in terms of its biophysical (natural) and socio-economic components and their anthropogenic interactions. We identified multiple criteria and indicators for this task, but then reduced these according to responses given by 60 experts in domains related to spatial planning. We used the selected criteria and indicators to develop environment fragility indices for each territorial administrative unit (LAU2) in Gorj County in south-western Romania. The resulting indices reveal quite large spatial variations in fragility and evidence that highly fragile human and physical environments are to some extent intertwined. In this respect, such environmental components as climate, soils, ecosystems, natural hazards and economic issues provide constraints on human activities, whilst humans themselves can, without sufficient care, increase fragility and adversely affect the quality of living environments for present and future generations. We also explore how such estimates of natural and anthropogenic fragility might enable better specific planning for local and regional development that aims to ameliorate both environmental and human adversity in an integrated way.

Keywords: *fragility index, mining area, specific spatial planning, Gorj County, Romania*

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1. Introduction

The numerous interactions between human society and its bio-physical environment tend to become more complicated over time (Harden et al., 2014). This is partially due to such factors as increasing population, an accelerating myriad of technological advances, and the shifting dynamics of various economic activities.

Mining activities in particular tend to affect adversely, both directly and indirectly, many human settlements and require careful territorial planning. Indeed, some mining activities are so harmful that the "environmental risks incline to migrate out of the area" (Vojvodíková, 2005, p. 51). In such territorial systems, it is very important to assess their environmental fragility before defining any specific features of territorial planning.

Increasingly, environmental studies demonstrate a clear focus on territorial risks, often involving trade-offs between such basic concepts as territorial vulnerability and resilience (Graziano and Rizzi, 2016). Moreover, there is an emergent preoccupation with defining environmental fragility in different territorial systems. For example, a recent study by Macedo et al. (2018) defines fragility as an "interaction between vulnerability and anthropogenic influences" (p. 1268) and develops an environmental fragility index applied specifically to the neotropical savannah biome.

In this study we attempt to define a complex fragility index which incorporates the major component fragilities of territorial systems. This index is subsequently applied to a Romanian region that is environmentally damaged by mining activities, and discusses how better planning systems can help remediate conditions.

We focus, in particular, on Romania's Gorj County, where the socialist Ceauşescu regime greatly increased energy production based on lignite to expand industrial production.

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The post-socialist dynamics of all East-European countries have witnessed strong de-industrialisation processes involving the closure of many large enterprises, including mining areas activities, the majority of which can be categorised as brownfield sites (Kunc et al., 2014). Romanian investors find such regions unattractive, especially on account of their environmental problems.

Taking into account the multiple consequences of de-industrialisation processes (Ianoş, 2016) and the lack of clear responsibilities for land rehabilitation, the affected human settlements need careful spatial planning (Cocheci, 2016) to enhance their revival prospects. Thus our approach focuses on evaluating the form and origin of local environmental fragility and how it might be managed. This task also engaged people working on spatial planning and research activities for local and regional administrations, all of whom have important environmental and planning knowledge on which we have drawn.

2. Theoretical background

Recent decades have witnessed many studies on both local and global environmental harms generated by such processes as climate change, rapid urbanisation, economic globalisation, and enhanced transport or communication technologies. The resulting environmental degradation decreases long-term sustainability and contributes to deepening spatial disparities in overall environmental quality (Salvati and Zitti, 2007). Consequently, land remediation strategies adopted by human communities to restore valued ecosystems (Song et al., 2018) may need to vary from place to place, a task that may become difficult where human activity has exceeded the environment's resilience capacity.

Fragility, which may be regarded as the inverse of stability, is an inherent characteristic of any ecosystem, regardless of the amount of disturbance to which it is exposed (Nilsson and Grelsson, 1995). Thus, the biophysical environment acts as a potential constraint on human activities and vice versa, introducing an element of environmental determinism into our arguments (Robinson, 2004). In ecology, for example, the concept of limitative factors (Odum et al., 1971) states that the presence and success of organisms depends on several different conditions and any condition which surpasses a tolerance limit will be considered a limitative factor. As a result, certain environmental conditions may be considered limitative factors for the development of either anthropogenic or natural ecological systems, thereby constraining human activities (Mac, 2003). Thus geologic, geomorphologic, climatic, hydrological, pedological or biological elements (Douglas, 2013), are all potential limiting factors in describing a site's suitability for different human activities (Pătroescu et al., 2012). In this context the estimation of fragility could be a key element for adopting specific procedures for planning social-ecological systems (Petrosillo et al., 2006).

Consequently, a decrease in environmental quality due to the overexploitation of mining resources, may affect the communities' capacity to survive in such conditions. It therefore becomes necessary to define a specific environmental concept, namely the fragile environment, which may suffer seriously adverse impact by small changes to key environmental or human variables. The management of this type of environment entails political, economic and social processes (Wyant et al., 1995; Oikonomou et al., 2011), which target ecological conservation and renewal while taking into account the new resources needed by existing communities. This task is often made both complex and difficult because of clashes between differing perspectives and strategies across many different spatial scales: global, national, regional and local (Drummond et al., 2015). For local and sub-regional authorities to take the best planning decisions in the case of fragile environments, including those damaged by mining activities, it is also very important to acknowledge the interactions between biotic and abiotic components, between the terrestrial and aquatic ones (Omernik and Griffith, 2014), and between the internal and external environments of territorial systems.

Political systems, which have until recently focused mainly on macro-level strategies, should also, according to Lange Salvia et al. (2019) look at the regional and local levels. And this task is likely to involve developing strategies to enable local and economically specialised communities to adapt to new conditions. The issue of likely irreversible climate change, however, is likely to complicate the management of fragile environments, requiring new strategies to allocate financial, social, economic, cultural and other resources to effectively improve both environmental quality and place prosperity in mining areas (Carvalho, 2017).

Some of the most adversely affected local communities in terms of environmental quality may well be those where national strategies for energy development require acceptance of drastic changes in land use. Communities depending on surface and underground mining or oil exploitation may have witnessed a temporary rise in economic well-being (Cocheci et al., 2015), but also often with strongly negative impacts on environmental quality (Zobrist et al., 2009; Wasylycia-Leis et al., 2014). Landscape reconstruction and ecological renewal require the transformation of degraded environments into high quality ones by improving ecological amenities, while simultaneously seeking to ensure sustainable development in local communities (Zhang et al., 2011).

The old 'man/nature' unity paradigm has been reinforced in the last fifteen years, although many years ago such analysts as Commoner (1971), and Bonnefous (1970) realised its complexity. This approach involves the morality and ethics of the space and place (Ianoş et al., 2010) and represents an important component in looking for a new paradigm concerning human-nature relations. Humans continuously seek to reduce fragility imposed by the natural environment, by moderating its various limiting factors. Such approaches however frequently impact negatively on environmental quality (Iojă, 2008). To make matters more complex, some human activities may negatively affect others. For example, areas with mining industries may impose negative externalities on landscapes and adjacent residential districts (Pătroescu et al., 2012) and adversely affect their quality of life. Health problems, for instance, are often caused by poor air quality (Gyourko et al., 1997; Douste-Blazy and Richert, 2000; Dumitrache, 2004). Hence, areas affected by anthropogenic environmental degradation may also be considered fragile environments, as they are characterised by significantly lower quality of life. Furthermore, activities such as open-pit mining or heavy industry may limit agriculture potentials or the possible development of other economic activities such as recreation and tourism locally or in adjacent areas (Spasić et al., 2007). Abandoned mining areas are particularly problematic since the realisation of new development is often associated with the high cost of site remediation (Stanilov, 2007).

Attracting investors willing to fund site decontamination and reconversion can be difficult (Constantinescu, 2012), unless remediation is sensibly required of mining companies for development consent in the first place.

Best practices in environmental management, acquired experientially over many centuries and subsequently incorporated in effective and legally enforced regulatory practices, have been the main instruments used to reduce environmental degradation. Such practices have targeted both natural environments and communities affected by the negative externality effects of various anthropogenic actions (Douglas, 2013). The latter case includes such spatial planning provisions as building restrictions to protect naturally fragile floodplains (Douglas, 2013), valued ecologies, or sanitary well-being (Ianoş et al., 2017). Thus, conservation interests can lead to the declaration of certain terrestrial or marine areas as natural protected zones characterised by specific land use development restrictions (Figueroa and Sanchez-Cordero, 2008). Such human-nature interactions often lead to spontaneous re-naturalisation or the targeted ecological renewal of degraded areas, processes that can be kick-started by defined strategies aimed at rebalancing the relationships between the two domains.

Generally, four major approaches can be identified in ecosystem restoration (Primack et al., 2008): no human actions; rehabilitation of some ecosystem structures and functions; partial spatial restoration; or complete (i.e. holistic) restoration. The last of these dimensions, which seeks the integral reconstruction of an ecosystem's structure and functions – or in other terms its natural capital – frequently neglects important social and economic dimensions (Aronson et al., 2006; Clewell and Aronson, 2013). On the other hand, re-naturalisation, which evolves spontaneously and naturally without any human intervention, may lead to the emergence and development of a different but sustainable ecosystem to the one destroyed. This aspect is essential for urban and territorial planners who, having a holistic and integrated professional background, understand both the systemic relationships between city, region, urbanity and environment (Glikson, 1971) and the processes by which ecosystems themselves evolve.

In situations where the physical environment was so drastically changed that native species cannot regenerate, as in the case of open-pit mining, ecological restoration can occur only if preceded by redistribution of the overburden removed, the addition of soil, water and nutrients, and the elimination of invasive species (Primack et al., 2008). As such, re-naturalisation, part of a cyclical phenomenon specific to territorial dynamics, included in the larger framework of territorial succession, often seems an easier and less expensive solution. Alternatively, the most effective environmental renewal strategy in some districts in terms of cost and acceptability of outcome might involve a mixed combination of ecological restoration and re-naturalisation.

Both ecological restoration and re-naturalisation can be regarded as approaches aimed at the ecological renewal of mining areas where the ecosystems have been affected by natural or anthropogenic disturbances. Hence, both renewal models can be regarded as possible measures to be included in spatial planning and environmental policy documents, to mitigate environmental degradation in such fragile areas. We considered that Romania's Gorj County, the NUTS3 county experiencing "Romania's greatest anthropic interference" (Braghină et al, 2008, p. 9), would be a suitable study area to test the possible application of the environmental fragility concept. Thus, our aim is to define the concept of a fragile environment and propose an environmental fragility index as an integrated measurement tool for the environment, to be used in designing specific planning instruments to tackle these issues, with a special focus on ecological renewal measures as the basis of targeted environmental policies.

In their scientific approaches, some scholars focus on the success factors for brownfields re-development (Frantál et al., 2015) and, indirectly, on the areas affected by de-industrialisation. In this context, we have only carried out interviews with specialists involved in spatial planning, in order to consider their vision on the most important factors that define the environmental fragility for this specific mining area.

3. Study area

Gorj County is located in Romania's South West region (see Fig. 1), and is the most important region for Romania's energy industry due to its high capacity hydroelectric power plants and coal-fuelled power plants (Cocheci, 2016). Coal-based electricity production decreased nationally from 40% in 2008 to 27% in 2014, however, due to the increasing proportion of renewable energy. Wind power contributed only 0.1% in 2008, but rose to 9.0% nationally by 2014, while hydro-energy rose 3% in the same period (Romania's Statistical Yearbook, 2016).

With a surface area of 5,602 square km, or 2.5% of Romania's national territory, Gorj County has a resident population of 336,995 inhabitants or 1.68% of Romania's total (National Institute for Statistics data, 2013). This county, which represents a NUTS3 (Nomenclature of Territorial Units for Statistics) unit at the European level, comprises 70 communes, although 45% of its population is located in the county's nine cities. Four of them – Motru, Rovinari, Ţicleni and Bumbeşti Jiu – are mono-industrial in the sense that a major part of their economies and employees are concentrated in a single industrial sector or even one industrial company (Dumitrescu, 2008). Their key industries are, respectively, coal production, electrical energy, oil production, and industrial machinery.

Gorj contains over 70% of Romania's stock of inferior lignite coal (Braghină et al., 2008) which feeds the high capacity power plants at Rogojelu and Turceni. Located in the Rovinari area, this lignite basin is characterised by open-pit extraction with significant environmental impact (Cuculici et al., 2011). Over 62% of Motru's morphology was transformed by coal exploitation (Titu and Balaszi, 2007). The restructuring of the mining areas, in which all underground and some surface exploitations were closed after 1996, had a great impact on villages whose economies depended heavily on open-pit mining (Braghină et al., 2011). The Romanian strategy for the mining industry for 2017–2035 (Ministerul Economiei, 2017) is an example of the attempt to overcome the economic and social disruption caused by the cessation of mining activity.

In 1999, the national government designated three 'deprived areas' in Gorj County, all related to mining activities. They were Schela (anthracite), Albeni (oil and natural gas) and Motru-Rovinari, already mentioned as Romania's main lignite coal basin. They were given special financial and fiscal support designed to stimulate investment, including 10 years without taxes for local business profits, and land for new investment. The strategy's impact was not in all cases as effective

Fig. 1: Location of the case study area at the national level (Romania). Source: authors' elaboration

as expected and, consequentially, the mining industry's contraction in such areas has affected the county's economy with considerable adversity (Popescu, 2000). As a result, the main dependence of the county on mining may represent a high risk from an economic and social point of view, especially over the medium to longer term (Braghină et al., 2010). Besides the negative environmental impact of mining, particularly the open-pit lignite quarries (Spasić et al., 2007), the county is also confronted with other environmental issues. Some mountain and plateau areas are vulnerable to natural flooding (Minoniu, 2011), whose effects are aggravated by such human activities as deforestation and quarrying. Frequent torrential rains are the main cause of these hazards (Marinică and Marinică, 2013). Romania's entire South-West region has experienced intense land cover changes in the last 25 years (Petrişor et al., 2010), which, combined with heavy rainfall, also increase its vulnerability to geomorphologic hazards, and especially landslides (Glade, 2003).

The County Territorial Plan developed in 2009–2011, which is the latest territorial planning document approved for Gorj County, included both a development strategy and several environmental measures: air, water and soil pollution regulations; mitigation of floods and landslides; protection of natural areas; and even the ecological reconstruction of mining areas (UAUIM, 2011). Unfortunately, there is no monitoring of these measures. Many current planning instruments in Romania lack the necessary mechanisms for implementation, especially concerning the financing of the proposed measures (Ianăşi, 2008). They are also poorly integrated with specific national environmental policies. The county environmental agencies check the implementation process, but the penalties for the offenders are too low to ensure a high level of compliance, thereby imperilling both governments and their strategies.

4. Methodology

4.1 The fragile environment concept

Throughout history, society has had to learn to adapt to evolving environmental constraints caused by either anthropogenic actions or extreme natural events (Douglas, 2013). Starting from the territorial system concept, we defined two analytical sub-systems, natural and anthropogenic, the first offering finite sets of resources to the second, which in turn has a considerable capacity to transform and capitalise on them (Ianoş, 2000b). Consequently, the territorial system conceptualisation aids us in analysing the fragility of the environment, taking into account both biophysical and socio-economic factors in particular places. The uncontrolled exploitation of natural resources and the lack of a clear land use policy may also create disequilibrium between the support capacity of the natural subsystem and the consumption of resources by local and regional communities. Such an imbalance may lead to modified ecosystems having a negative impact on human well-being, and enhanced fragility, which may at some point morph into a phase of creative destruction (Holling, 1973).

Our approach tries to develop a new dimension of environmental fragility, taking into consideration the high complexity of the internal and external environments of a territorial system, and including both natural and anthropogenic components. This is a complementary approach by comparison with other uses of the fragile/fragility concept, developed by different authors, which reflect more or less the connection with a diversity of territorial policies (Petrosillo et al., 2006; Baliamoune-Lutz and McGillivray, 2008; Ferreira, 2017; Yu et al., 2018). Each territorial system is not isolated, having structural and functional relationships with surrounding territorial systems. Both internal changes and external perturbations may disturb fundamental relationships between natural and anthropogenic sub-systems in a particular territorial system. Unbalanced changes inside a territorial system, because of overexploitation and limited eco-services, can modify the initial state and transform the internal environment in a fragile one. Because any territorial system is connected with other surrounding territorial systems, its own fragility can induce asymmetric flows of mass, energy and information between it and adjacent areas.

Consequently, complex interactions between the internal and external environments may increase environmental fragility, both natural and anthropogenic, at larger

spatial scales. Such events can be very important for local and regional development (Ianoş et al., 2013), because effective management of fragile environments requires the implementation of specific territorial planning measures at different spatial scales simultaneously, as shown in Figure 2. Such a management process is alas a difficult task given issues such as regional diversity, system complexity, persistent and often unsympathetic human-environmental interactions, inevitable information deficiencies, and the presence of many lagged effects.

Given these complexities, a major question concerns the capacity of the fragile environment concept to be useful for both spatial planning and environmental policy. Effective management of complex problems can only result from improved understanding of that complexity and, as far as possible, its measurement. Insofar as it helps differentiate both the ecological and societal problems of particular areas and suggests policy avenues for their amelioration or enhancement of sustainability, we consider the concept worth investigation. We can further identify two types of fragility: current and latent. Given that many physical environments have an inherent capacity to revert resiliently to previous configurations, current and latent fragility overlap to some extent. The analysis of anthropogenic issues, however, is heavily weighted to current statistics rather than latent statistics. For example, place accessibility can be measured in terms of current modes of transport – their cost, convenience, service frequency, likelihood of hazards, and so on. In the future, the quality of internet connectivity could be far more important in adapting to a transformative high-tech world or, alternatively, new forms of physical transport might emerge. Likewise, local cultures that are risk accepting, entrepreneurial, and future-oriented might be far more important for local development prospects than more conventional measures of economic and social well-being. This theoretical approach is not the target of the current paper, however, postponing it for the future.

4.2 Methodological approaches

Taking into consideration (indirectly) the selected case study, we established a methodology to identify and quantify different types of fragile environments on the basis of agreed indicators and techniques for measuring the most relevant environmental components. Such analysis raises the possibility of tailor-made spatial planning measures at different scales, especially local and regional, as shown in Figure 3. Based on our definition of the fragile environment concept, we realised a set of environmental fragility types and associated criteria. In parallel, a set of criteria and indicators were proposed, with their relevance being tested

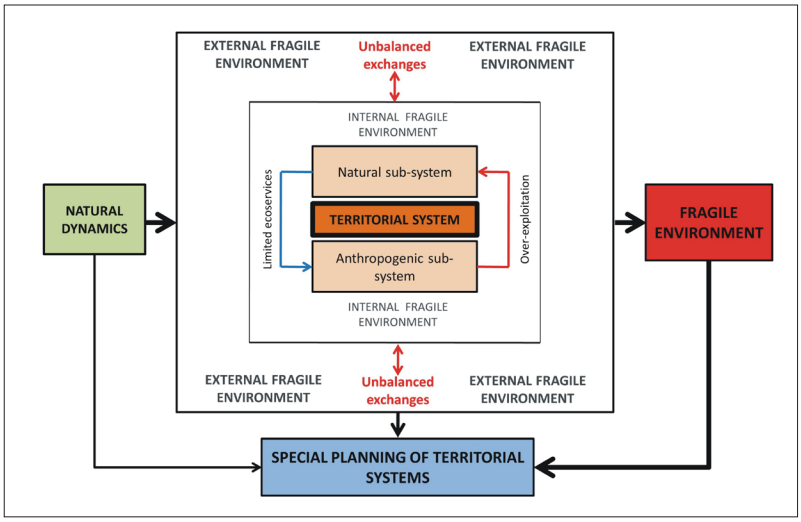

Fig. 2: The fragile environment concept. Source: authors' conceptualisation

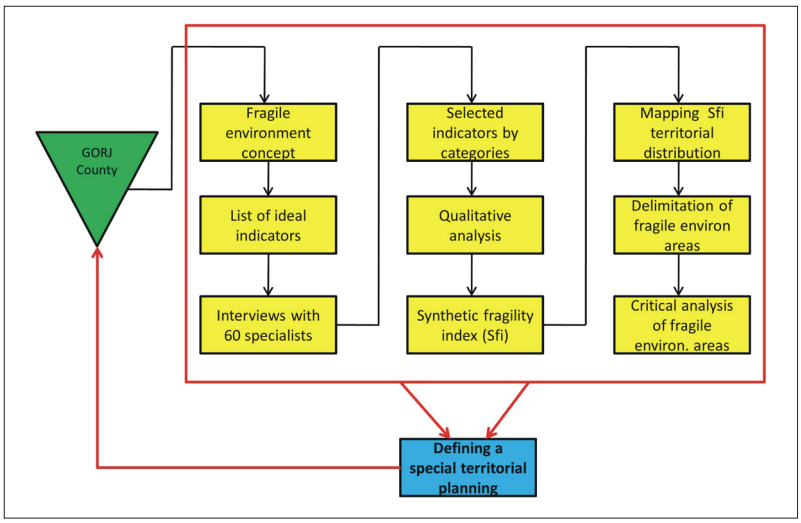

Fig. 3: Methodological steps in defining specific territorial planning processes in a fragile environment Source: authors' conceptualisation

in terms of the 60 responses we received from the survey of specialists in territorial planning. The specialists were selected from our network of professionals involved in spatial planning activities, regardless of their profession. The aim of the questionnaire was for the experts to grade each criterion from 1–10, without knowing the study area on which the analysis would be made. As a result of this expert assessment, we concluded that the number of indicators is less important compared with their perceived relevance to the quantification of environmental fragility. Consequently, we associated one criterion to each type of environmental fragility, with each criterion being measured through the most relevant indicator (also according to available data at local level). Consequently, we realised a list of indicators that represented the basis for our spatial analysis.

The next step was the qualitative analysis of these indicators, thus obtaining a synthetic index of environmental fragility, spatially constructed at county level. Based on the principle of territorial contiguity, the areas considered to be fragile environments were thus identified. The critical analysis of these areas revealed distinct territorial particularities. These, in turn, should be taken into account in shaping specific territorial planning measures designed to ensure improved sustainable development at the level of these newly-defined territorial aggregates.

4.3 Criteria and indicators

The methodology used for selecting criteria and indicators at the local level is similar to the one previously used to determine environmental restrictiveness at a regional scale (Cocheci, 2016). In order to quantify environmental fragility in areas suffering from different types of environmental issues, as described above, we first proceeded to define a typology of fragile environments, based on our literature review regarding the influence of different factors on environmental fragility (see Tab. 1). We identified nine types of fragile environments, focusing on different aspects of the environment: six describing natural fragility (from geological, geomorphological, climatic, hydrological, pedological and biological points of view); and three describing anthropogenic fragility (from land use, socio-economic and legislative points of view).

For each type of fragile environment identified, between one and five criteria describing different aspects of fragility were selected, with a total of 27 criteria being considered, as shown in Table 1. A questionnaire was designed and distributed to 75 experts in various domains related to spatial planning, with the aim to rate these criteria on a scale from 1 to 10 based on their importance. In the end, 60 specialists answered our survey. The structure of the questionnaire enabled them to comment on some items, which was useful

No.	Fragility Type	Criteria for definition (source)
1.	Geological fragility	High seismicity (Lang et al., 2012)
		Sedimentary rocks which hamper foundation (Klein et al., 2013)
		Small depth of groundwater (under 2 metres) (Klein et al., 2013)
2.	Geomorphologic fragility	High altitudes (over 1200 m) (Bathrellos et al., 2012)
		High relief fragmentation (Haddaway et al., 2013)
		Presence of landslides (Papathoma-Köhle et al., 2007)
		Presence of ravines
3.	Hydrological fragility	High incidence of floods and flash floods (EEA, 2010)
		Low quality of surface water caused by pollution (Ongley and Booty, 1999)
		Low quality of groundwater caused by pollution (Stamatis et al., 2011)
4.	Climatic fragility	Incidence of Drought (Tánago et al., 2016)
		Negative extreme temperatures (EEA, 2010)
		Positive extreme temperatures (EEA, 2010)
		Low air quality caused by pollution (Douste-Blazy and Richert, 2000)
5.	Soil fragility	Soil contamination caused by pollution (McClintock, 2012)
		Land degradation due to soil erosion (Cerdan et al., 2010)
		Low soil fertility (Sanchez, 2002)
6.	Biological fragility	Presence of protected species and habitats
7.	Fragility related to land use	Major land use changes (deforestation, urbanisation, etc.) (Popovici et al., 2013)
		High degradation of land by human interventions (quarries, tailings dumps etc.) (Spasić et al., 2007)
8.	Socio-economic fragility	Low turnover per inhabitant (Pavel and Moldovan, 2016)
		Low level of education (Ramos et al., 2012)
		Low accessibility (Caschili et al., 2015)
		High level of land abandonment (Shengfa and Xiubin, 2017)
		Declining population (Martinez-Fernandez et al., 2012)
9.	Fragility of the environmental legislation	High proportion of natural protected areas (Geldmann et al., 2015)
		High surface occupied by sanitary protection areas

Tab. 1: Types of fragility (partial fragilities) and related criteria
Source: authors´ compilation

in suggesting better methodological approaches. The average ranking for each criterion was defined by dividing the sum of total answers by the number of specialists. So, the value for criterion i (Vc_i) was:

$$Vc_i = (\sum V_{ij}) / 60,$$

where V_{ij} = the rating given by each specialist j ($1 \geq j \leq 60$) to criterion i ($1 \geq i \leq 26$).

In summary, for each of the nine dimensions of a fragile environment previously defined, we selected the criteria with the highest expert ratings, reducing the number of them from 27 to 8. The resulting criteria were then expressed by 8 indicators (one for each criterion) defined according to data found in official sources, research studies or the latest planning documentations, at LAU2 level (Local Administrative Unit 2 – municipalities or equivalent units, after the European Union classification of administrative units in effect until 2017). Eventually, all indicators were normalised (with 100 being the maximum value for each category), using the formula:

$$V_s = V_r / V_M \times 100,$$

where: V_s = standardised value; V_r is the current value; and V_M is the maximum value of the values' chain.

For each LAU2 level unit, the fragility index (Fi) was defined as the sum of standardised values of all indicators. The process of summing the standardised indices makes the implicit assumption that all variables of fragility are weighted the same. At the same time, some of variables have a positive impact on fragility (as against increasing it), and others a negative one (increasing the fragility). This procedure accounts for the summation that is obtained, taking into account the issue of "+" positive variables and "–" negative variables. Computing the fragility index for each LAU2 unit, and analysing the entire value's chain, we individualised two main disruptions inside of the values' distribution. Having evaluated the fragility index for each LAU2 level (commune), we first divided the scores into three classes – high, medium and low – and then mapped their locations. In a second stage of the analysis, we designated as highly fragile any locations within Gorj County where three contiguous LAU2 units (Ianoş, 2000a; Cocheci, 2017) could be identified. Such regions were subsequently compared those parts of the County previously identified as 'deprived areas' in 1999.

Based on the analysis at the county level, we depicted the possibilities for implementing ecological renewal as a planning approach in fragile environments, taking into consideration several of the current legislative frameworks in Romania. By using such a synthetic index, territorial planning might become a real support for disadvantaged rural areas, for their better adaptation to environmental challenges, such as land degradation, climate change, population ageing and economic changes (Mocanu et al., 2018).

5. Results

Using a questionnaire survey, we received responses from different experts related to spatial planning: human geography (18), urban planning (16), environmental sciences (16), sociology (6), architecture (2) and engineering (2). Most of the experts (48) worked at a university and/or its research centres, while the other 12 worked in private companies. Furthermore, about half of the experts questioned (34) had at least 10 years experience in the field. Table 2 illustrates the selected criteria that received the highest average score (taking into account all expert ratings), along with the indicators that we used for quantifying each criterion at LAU2 level and the data sources that we consulted. We used data from the latest existing studies at county level (regarding environmental quality assessment and spatial planning documents: see Tab. 2). The analysis for each fragility

Fragility type	Criterion	Score	Indicator	Source
Geological	High seismicity	7.86	Highest value of terrain acceleration for earthquakes with average return period of 100 years: acceleration index decreased from south-eastern (0.16) to north western (0.08) communes.	Master Plan of Gorj County (2011)
Geomorphological	Presence of landslides	8.76	Number of landslide areas (over 200 square metres) in LAU2 unit. The highest values are registered in Bustuchin and Rosia de Amaradia (seven landslides).	County Plan of Risk Analysis and Coverage (2009), amended by field investigation
Hydrological	High incidence of floods and flash floods	8.79	Presence/absence (on rivers, flash-floods or both).	Master Plan of Gorj County (2011)
Climatic	Low air quality caused by pollution*	7.52	Presence/absence of sources of air quality degradation.	County report regarding environmental quality (2013)
Pedological	Soil contamination caused by pollution	7.24	Number of contaminated sites in LAU2 unit: 155 contaminated sites are located in Gorj County, concentrated in just 24 LAU2 units.	Regional Action Plan for the Environment 2014-2020
Land use	High degradation of land by human interventions – coal quarries, tailings dumps etc.	7.69	Surface of degraded land (ha). Only Godineşti commune has no degraded land, in comparison with Câlnic and Mătăsari with over 1900 ha of degraded land each.	National Institute of Statistics data (2013)
Socio-economic	Low accessibility	7.86	Accessibility index (one point for each identified transport infrastructure problem).	Master Plan of Gorj County (2011)
Environmental legislation	Natural protected areas	7.79	Percent of Natura 2000 SCI site area from total LAU2 units' areas.	Ministry of Environment dataset, GIS analysis

Tab. 2: Selected criteria and indicators used for quantification
Source: authors' compilation

type (partial fragility) showed an overlapping between the most-quoted biological fragility criterion (presence of protected species and habitats) and the legislative fragility one (natural protected areas). In this case, we decided to take only one of them into account when calculating the fragility index, and we have selected 'the natural protected areas' as characterising the Legislative fragility type. The main argument was that natural protected areas enclose the majority of protected species and habitats, conforming to several Romanian laws and norms. This means that we kept only eight criteria (eliminating the biological fragility) and eight of the most relevant fragility indicators.

A Fragility Index was computed for each LAU2 unit by summing the standardised values, recognising (and assuming) that each of the 8 variables was weighted by the respondents at roughly the same level. Theoretically, the fragility index value is contained in the general interval from 0 (no fragile features) and 800 (summed maximum value registered for each of the eight selected criteria).

The fragility index, calculated using the normalised values of the above-mentioned indicators, registered values between 116.60 (commune of Săuleşti) and 507.02 (town of Tismana). The upper tertile of the data series (i.e. 33% of the population is less than or equal to the 33rd percentile value) included 23 LAU2 units (fragility index value of at least 340), based on which we defined four different fragile areas, each containing at least three contiguous LAU2 units (see Fig. 4 and Tab. 3). Taking into account the average size of each LAU2 unit (commune), we consider that for this county an area is significant enough if it has a total surface of more than 150 square kilometres.

An analysis of the spatial distribution of the fragility index within Gorj County shows high values in the northern part (due to natural features – mountainous area with low accessibility and a high density of protected species), as well as the high values within 7 of the 9 cities in the county – especially industrial or mining cities such as Rovinari, Bumbeşti-Jiu, Ţicleni or Târgu Cărbuneşti. The fragile areas that we identified are closely related to important mining areas in the county, as further discussed in the next section.

The four fragile areas contain 18 LAU2 units (approximately 25% of the county's administrative territorial units), four urban and 14 rural. In three of these fragile areas, the fragility source is an anthropogenic one and is related to mining: open-pit coal-mining (Rovinari

Fragile area	LAU 2 units	Main fragile elements	Source of fragility
Rovinari	Urban: Rovinari Rural: Bâlteni, Câlnic, Fărcăşeşti, Mătăsari, Negomir, Urdari	Air pollution (all), soil contamination (Bâlteni), land degradation (Mătăsari, Câlnic)	Coal mining
Ţicleni	Urban: Ţicleni, Târgu Cărbuneşti. Rural: Licurici	Air pollution (all), soil contamination (Ţicleni, Târgu Cărbuneşti), Low accessibility (Ţicleni)	Oil and natural gas extraction
Amaradia Valley	Rural: Căpreni, Cruşet, Hurezani, Stejari, Turburea.	Air pollution and seismicity (all), low accessibility (Stejari), soil contamination (Turbure)	Oil and natural gas extraction
Parâng	Urban: Novaci Rural: Crasna, Baia de Fier	Air pollution (Novaci, Crasna – wood industry), Protected areas (all), low accessibility (Baia de Fier)	Natural features (mountainous area)

Tab. 3: Fragile areas in Gorj County. Source: authors' categorization

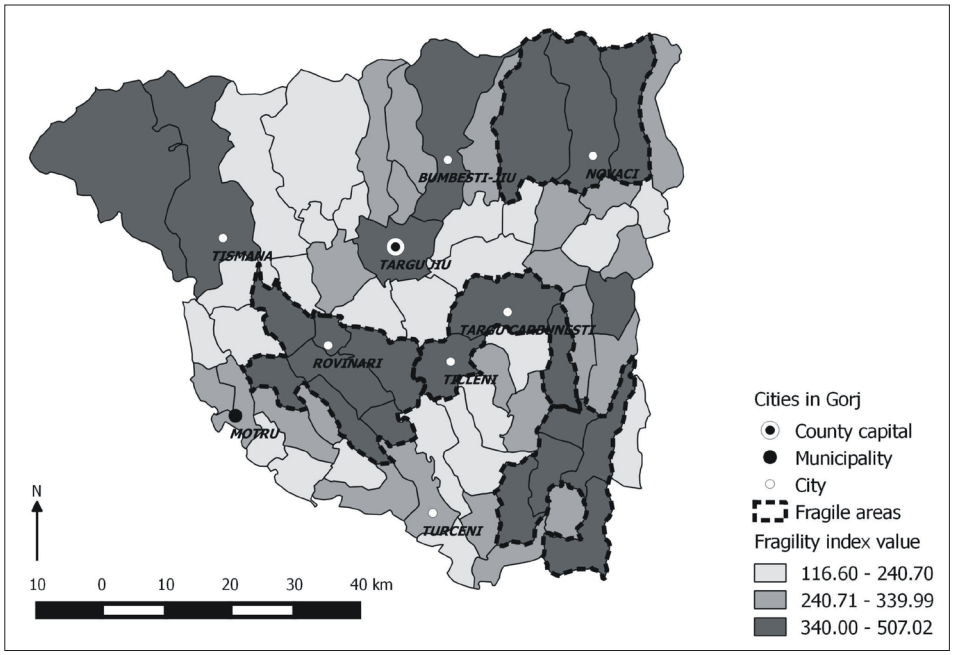

Fig. 4: Fragility index at LAU2 level and delimitation of fragile environmental areas Source: authors' categorisation

fragile area) and oil and natural gas extraction (Târgu Cărbuneşti and Amaradia Valley areas). This confirms the significant environmental impact of the county's energy industry, as stated in the description of the study area. This is mostly caused by the high capacity power plants' main source of energy, which is the lignite coal in the Motru-Rovinari basin.

A more detailed analysis of the existing fragile elements in the four fragile areas that we identified highlights the problem posed by the mining industry to air quality and soil contamination (Rovinari, Ţicleni and Amaradia Valley fragile areas), with the coal industry (Rovinari area) also responsible for significant land degradation due to open-pit mining. The situation is different in the Parâng fragile area, where fragility is mostly related to the presence of natural protected areas (with many protected species), and the low accessibility caused by the natural features of the territory (mountainous area).

6. Discussion

Starting from the fact that Gorj County has a special territorial structure, with a diversity of fragility types, and with a strong restructured mining activity which has asked for government decisions favourable for further development, we have considered that this is a good sample location in which to apply our methodology.

6.1 Comparative analysis between fragile areas and deprived areas

A Romanian law enacted by the National Parliament in 1999, defined deprived areas as being characterised by at least one of the following conditions: (1) the existence of mono-industrial productive structures accounting for 50% or more of the region's total employees; (2) over 25% of the employees in the area affected by collective layoffs due to the restructuring of economic units; (3) an unemployment rate 30% or more higher than the national average; or (4) isolated areas with poorly developed infrastructure (Cocheci, 2015). The financial incentives offered to firms established in these areas did not have the expected impact, however, and did not lead to the economic development of the deprived areas (Săgeată, 2012).

The comparison between the fragile areas identified and the deprived areas in Gorj County shown in Figure 5 thus illustrates the connections between environmental fragility and social and economic issues.

Hence, seven out of the 13 LAU2 units in the Rovinari deprived area have also been included in the Rovinari fragile area, while the city of Târgu Cărbuneşti was included in both the Albeni deprived area and in the Ţicleni fragile area. This highlights the need for a better integration of sectoral policies at regional, county and local level, in order to tackle both environmental and social vulnerabilities. Taking into account that the territorial fragility is more connected with the anthropogenic influences generated by mining activities, for Gorj County, these areas constitute a priority in spatial planning.

Mine site abandonment is one of the situations in which the lack of control and minimal mitigation actions for environmental degradation result in great economic, social and environmental impacts. The fragility index confirmed our initial hypothesis regarding environmental issues in the mining areas of Gorj County, while the comparison with the deprived areas declared by law highlighted the link between environmental fragility and limited development possibilities. Considering the environmental degradation in such areas, we need to consider what spatial planning instruments, linked with environmental policy measures, and could be used to ensure a sustainable development of these areas in the future.

6.2 Implications for specific territorial planning

Apart from any recuperation alternatives, some development strategies may also have to focus on ensuring a high-rate exploitation of the natural resources. We should also admit that effective management of these themes is a 'whole-of-society' issue involving all tiers of government, private business, media, various kinds of

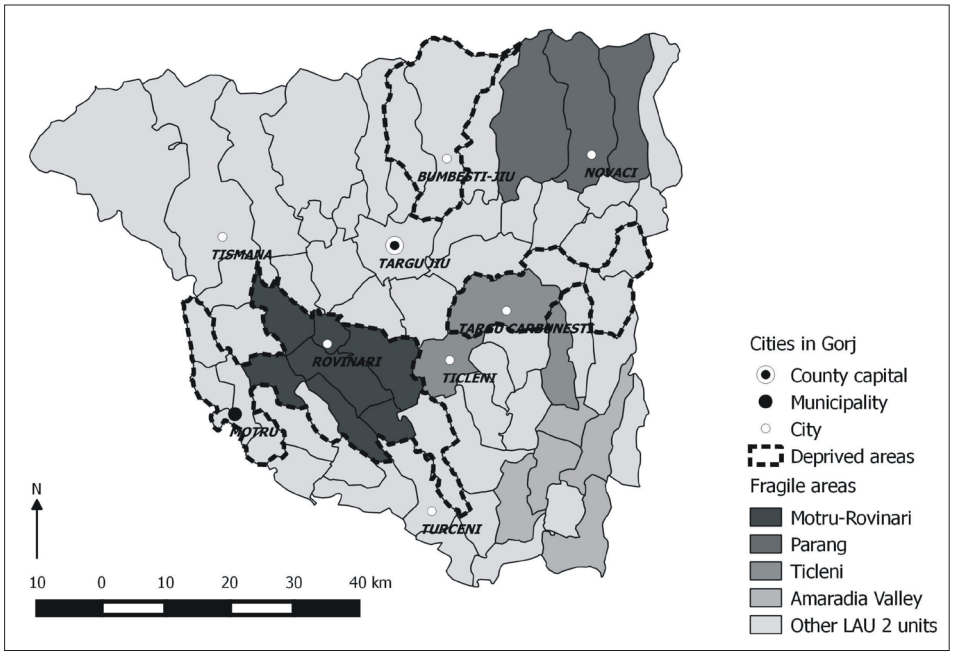

Fig. 5: Comparison between fragile areas and deprived areas in Gorj County
Source: authors' elaboration

social institutions, individual activists, and so on (Yaskal et al., 2018). It requires strong leadership across all of these dimensions and strong networking to, in effect, mould people's culture in the direction of caring passionately for environmental quality and also seeking high quality local development. All this has to be underpinned by clear and strongly enforced regulation and education about the skills necessary to deliver preferred outcomes. So, effective planning and management are a multi-faceted and complex task (Sorensen, 2017).

In the case of Gorj County, the implementation of effective management frameworks requires coordinated actions among all relevant actors. These comprise local populations and associated community groups, business corporations, government authorities mainly at local and county level, and various national agencies dealing with such key arenas as environment, economic development, education and transport.

In practice, the main focus is likely to be on the cleaning of affected sites and on planning their re-use. In mining areas, the rehabilitation process should prioritise the reduction of environmental degradation by reducing landslide risks and by re-integrating the degraded land into the ecological circuit. This would be a significant contribution towards the improvement of local and regional environmental quality. A key element, however, is the long time – often decades – required for stabilising tailing dumps, as well as the very high costs associated with these actions (Spasić et al., 2007).

In a recent study, Bański et al. (2018) define for Poland, areas of strategic intervention, respectively growth areas and problem areas. For delineation of problem areas, at a regional level, they used 21 indicators equally covering natural, social and economic issues. The main finding regarding problem areas is that their identification is consistently useful for a better application of strategic planning. Our study, using another methodology, shows the importance for the fragile areas of defining special planning procedures to prioritise a sequence of actions to enable balanced territorial development.

Moreover, the legislative framework in Romania has covered these problems only partially, and not in an integrated manner. Most of the existing legislation regarding degraded environments does not have associated financial mechanisms, and thus relies only on state funding. Ideological factors also make such actions difficult to implement, since the closure of economic activities contributing significantly to environmental degradation often conflicts with the local population's need for jobs.

The mining activities located in Gorj County are operated only by a State Company: Oltenia Lignite Company, which has the responsibility to make rehabilitation of the areas degraded by coal exploitation. As only the costs for the affected areas are covered, all additional phenomena generated directly and indirectly by coal exploitation are left to be solved by local and regional authorities. In our view, the region's extractive industries work to the benefit of Romania as a whole and, therefore, the nation as a whole has a financial responsibility for environmental restitution, whether re-establishment of original ecologies or re-naturalisation, or some mixture of the two. National responsibility may go further and embrace anthropogenic renewal, including re-educating workers with new skills, as well as infrastructure improvements (e.g. health, transport, and so on).

In this context, the use of an environmental fragility index can aid in the identification of LAU2 units with significant environmental issues, thus underlining their common problems. Given the lack of clear and specific public policy in this arena, the creation of voluntary Intercommunity Development Associations (or Local Action Groups) could be a good opportunity for communes and small cities to act together in finding solutions and external financing opportunities for these common problems. The national government could help trigger such local actions financially, but national or regional private organisations could play a role. Modern regional anti-fragility requires a myriad of innovative approaches (Taleb, 2012). If some scientists have demonstrated, about one hundred years ago, a similarity of interactions between the four planetary surfaces and regional/local places (Ianoş et al., 2018), then why cannot we try to identify and to extrapolate the mechanisms of regional or local environmental fragility, in further approaches, to the global level?

Taking into account the problems generated by the permanent and huge interventions of the coal industry on natural and socio-economic components, the definition of specific planning processes for this area is fully justified. Such planning could facilitate the understanding and raise the awareness of the population and the territorial actors to simulate the effects of any important changes before they are made, and to establish short- and medium-term priorities.

7. Conclusions

A vision of development based on an eco-systemic approach (Vădineanu, 1998) considers territories transformed by people as a specific organisation level of the life on Earth, related to a vision exclusively focused on natural ecological system. Similar to individual living entities, human society is also limited in its development due to the constraints of fragile factors, which can often put the integrity of socio-ecological systems under doubt (as the pressure of inappropriate economic activities dramatically decreases the quality of environmental services). The complexity of operations required in the ecological renewal approach to a human-changed territory requires a careful analysis of the social and economic subsystems in that area, in order to find a new desirable equilibrium between the natural and socio-economic systems. In this approach, a simple dereliction of the resource extraction sites generates strong restrictions on the development of the human communities.

Consequently, the forced industrialised areas in the 1970s and 1980s in Romania require a controlled re-naturalisation of the derelict lands, followed their de-industrialisation by adequate central government financial, administrative and scientific resources. Hence, the decisions regarding ecological renewal approaches need to become an important part of territorial development and environmental policies. While the case study area involved a Romanian county, the environmental issues related to mining areas in a post-industrial and a post-socialist context can be extended to other examples in Eastern Europe as well (Stanilov, 2007). In the cases of closed mining exploitation, especially the case of open-pit mining, the alterations of the physical environment long with the re-distribution of land use in such areas affected by re-naturalisation processes, can have important impacts on the settlement network, as well as on the quality of life and life-styles of the local population.

The proposed index of environmental fragility, referring to different environmental fragility aspects of the environment (geology, geomorphology, hydrology, climate, soil, society and its impact), can be used as a tool designed to integrate the analysis of the structural and functional elements of both the natural and the anthropogenic sub-systems. These elements are included within the proposed aggregated index, which could offer a real tool for local and regional authorities and, especially, for those facing the mitigation of closure effects of the mining activities. The strong point of this index is the fact that it offers a comparative view on the affected territory and aids in the differentiation of the local communities in their efforts to have a new environmental quality.

The measurement of the environmental fragility index at local and regional level shows that some areas in the county, especially rural areas, face significant environmental and socio-economic problems, with most of them also being part of the deprived areas declared by law in 1999. In this regard, a first step would be for communes facing similar issues to become partners through the creation of Intercommunity Associations, which would aid them in financing larger projects together.

At the LAU2 scale of analysis, this index can be used in the elaboration of local and intercommunity strategies and policies. Nevertheless, the currently-used indicators to quantify the different fragility criteria could be improved, depending on the re-organisation of the collection data system at local level, as most of the studies realised at county level have started to be outdated. Adding new data series, especially those characterising natural phenomena such as imminent landslides, potential flood areas or even quality of air indices at LAU2 level, as well as enlarging the access of researchers and local administrators, could greatly aid in making environmental reconstruction more rigorous, appropriate and efficient.

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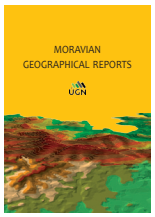

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SCIENTIFIC COMMUNICATION

The spaces and places of Czech believers

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Abstract

Geographical aspects of contemporary Czech religiosity are discussed in this paper. The main objective is to understand and approximate the spaces and places of faith which Czech believers inhabit, construct and reconstruct. An original focus on young believers was broadened to include priests, preachers and older members of several churches in Brno city, and the Přerov and Ústí nad Labem regions. Concepts of space and place, sacred spaces, and the imagery of post-mortem spaces are treated within the context of so-called secularisation and related phenomena. The methodology is based on an inductive qualitative approach using the Grounded Theory of Strauss and Corbin. The data are presented, discussed and ordered following the main themes originating from the research, including: (i) spaces of regular activities (related to the faith); (ii) spaces of dissemination and evangelisation of the faith; (iii) personal places linked with faith; and (iv) an introduction to the imagery of post-mortem spaces. The results document a long-term shift in the attitudes of believers, the change from rather public spaces of community gathering to personal places, influenced by specific secularisation tendencies. Also, the results represent the typical places of faith which are constructed and reconstructed by current Czech believers, and the current imagery of post-mortem spaces.

Keywords: *religiosity, space, place, secularisation, post-mortem spaces, Czech Republic*

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1. Introduction

This study examines the "spaces and places of the faith" and the phenomenon of secularisation, which serves as a guiding theme in this text, and presents several aspects of research on Czech religiosity. The thematic topic of secularisation underlies and to some extent accounts for the shift in using and perceiving spaces and places by Czech believers.

The "space(s)" and "place(s)" are extremely geographical terms, which have been dealt with for a long time by geographers, especially in the period of Humanist Geography and later by many other authors (Relph, 1976; Tuan, 1977, 1978; Seamon, 1979, 1980; DeCerteau, 1984; Vávra, 2010; Hynek, 2011; Siwek, 2011). This contribution also develops the concept of the "sacred place", which lies at the intersection of the geography of religion and geographical interest in spaces and places (Park, 1994; Smith, 2008; Šiler, 2017; Crosbie et al., 2018). A further revealed aim was to connect these thematic levels with the geographical study of the imagination of post-mortem spaces and the afterlife.

A major objective of this research was to deepen our understanding of the spatial imagery (as constructed and used by participants, i.e. not their 'imaginaries' nor 'imaginations' as commonly used in the geographic literature), of the practices of Czech believers, mainly Christians. More precisely, the goal is to orient our work to their "spaces and places of the faith", which are related in their everydayness but also in their exceptionality.

The spaces are created and re-created directly by the believers – places are then more specific, often static, more personal, and connected with geographies of the body and personal experiences. Some potentially fruitful findings emerged from the inductive qualitative research on the "imagined places": first, there are remote places, whether to pilgrimages or from personal experiences, to which the believers like to return in person or, due to physical distance, rather in their thoughts; second, the post-mortem places, which are imagined in a specific manner, in (dis) agreement with the particular Church dogma. Members of an "alternative religiosity" formed a secondary group, which was explored extensively for comparison with Czech

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Christians: the term is relatively ambiguous and includes colourful and variable scales of religious and quasi-religious attitudes: a) new religions – "new" in the Czech context; b) personal non-institutionalised spirituality, grouped under the notion of "alternative religiosity".

A secondary objective was to demonstrate that secularisation is related to processes of the shift in geographical spaces and places which are utilised by Czech believers over time. In the frame of a gradual exploration of the phenomena using the methodological design of Grounded Theory, this is the very theory which arose from the inquiry. A geography of spaces and places of the faith then becomes a specific time-space. Other (more general) goals consisted of an explication of the personal places of Czech believers, and an understanding of the imagery of post-mortem spaces and their geographical dimensions.

The research aims were fully specified in the use of a qualitative methodology (see details in the Methodology section), by semi-structured interviews and through analysis according to the procedures of Grounded Theory (Strauss and Corbin, 1990), and with the use of complementary methodological sources (Cloke et al., 2004; Disman, 2008; Hendl, 2005; Švaříček and Šeďová, 2007). Some authors have directly "challenged" researchers to a stronger shift to qualitative methods in inquiries about religiosity: Tichý and Vávra (2012, p. 7); Lužný and Nešpor (2008, p. 9); Bartolini et al. (2017).

2. Theoretical background: Spaces and places of faith

The theory is concerned with places, spaces and spatiality itself. Subsequently, I focus on the meaning of place from the point of view of selected authors (Relph, 1976; Tuan, 1977, 1978; DeCerteau, 1984; Vávra, 2010; Hynek, 2011; Siwek, 2011) to form a basis for the study of which spaces/places are important for believers, both individuals and communities. Brace et al. (2006) have also investigated communal identities in specific places around a sense of religious belonging. The following section is dedicated to the theme of "sacral places", focusing on how this issue can be utilised for the current research problem: how the spaces and places of Czech believers can be studied and how to approximate the processes involved in how spaces/places are constructed and reconstructed. These sacred places include places connected with the established Church (e.g. pilgrimage places), but also the personal places of each believer (Relph, 1976; Park, 1994). I also deal with the issue of post-mortem and other 'abstract faith' spaces, with an emphasis on "transcendent" places of the transition between two worlds: post-mortem imagined spaces or those related to afterlife practices.

2.1 Space and its interpretation

According to Siwek (2011, p. 32), humans do not perceive a void but the space via the objects and places, and uniquely with the help of those, evaluate also the characteristics of the space or its parts (relative space, in this case). Nigel Thrift (2003) divides the concepts of space into four parts:

a. empirical space (empirical constructions);
b. unblocking space (based on interactions);
c. image space (approximately equal to imagery in this paper); and
d. space connected with place ("place space").

The latter is understood as a place; but 'understood' is used only loosely since the nature of place is anything but fully understood (Thrift, 2003, p. 102). Place is more 'real' than space, a stance born out of the intellectual certainties of humanism and the idea that certain spaces are somehow more 'human' than others – these are the places where bodies can more easily live out (or at least approximate) a particular Western idea of what a human being should be in their being (Thrift, 2003, p. 102).

Castree and Gregory (2006) discuss the attitude of David Harvey, who emphasised the importance of public space and the seeking of space in its "spatialities" when creating any geographical imagery; moreover, he perceives the complexity of space as fortunate for research. According to Siwek (2011, p. 41), the most geographical feature is that space can be understood in various ways, whose combinations allow new views on "what is where" or "where" something happens. "Space" is often considered as a notion equal to "milieu" or "settings" by contemporary geographers, and for many it is a complex of variable views forming a "synergy". For others, it is equal to geometrical space or to the aggregate of spatial relations (Siwek, 2011, p. 41); but see also Thrift (2003, p. 102) who claims places are inseparable parts of the interactions in the real world.

2.2 Space as the net of lived places and the meaning of place

The trialectics of space (absolute – relative – relational), as described for example by Lefebvre (1991) or Hynek (2011) and then problematised by Gibas (2014), offer thinking on our world and explain that people do not inhabit abstract spaces, they do not live in space but they inhabit places (Gibas, 2014, p. 235). Tuan (1977, p. 3) says space means freedom while place is safety. The first tempts us, the second binds us. Although radically different, the "imagery of space and place need each other to be self-defined". From the safety and stability of place we are conscious of the openness, freedom and thread of space, and vice versa. For Tuan (1977), space represents freedom, which enables the rise/creation of places or more generally the opportunities which are accomplished through the places. Space is given to us through the places (or technically – objects), whether real or imagined, and its relative position, its relations. Space is defined as a net of places (Tuan, 1977, p. 12). Space without places would be just a non-practised and maybe frightening or even unreal possibility (Gibas, 2014, p. 235).

The final kind of space (according to Thrift, 2003) is space understood as place. Through the body, humans inhabit the world, through activities which are transformed into behaviour by human subjects. Sets of integrated behaviours which provide certain aims are called time-space routines or body ballet (Seamon, 1979). People entangled in time-space routines meet in time and space, they are going to know each other, starting to speak. Thanks to these interpersonal dynamics, which are considered taken-for-granted, space becomes place where humans maintain and create their own little parts (Seamon, 1979).

According to Hynek (2011, p. 22), places are elementary spatial units in spatial analysis, identifiable by coordinates and with relations to other places in the frame of spatial interactions. They have material objects and functions and are the basic building blocks of nets. Mutual relative distance between places is important, as well as overcoming it. The resistance between places can also disappear, however, and contacts then become difficult. Gibas (2014, p. 249) summarises these arguments in saying that both Geography

and Social Anthropology have gradually accepted the idea that people inhabit places rather than spaces, because the latter are in the process of permanent reconstruction, performance, questioning and experiencing.

Meanwhile, DeCerteau (1984) thoroughly discusses everyday practices in urban space and admits that spatial practices in fact 'secretly' structure the determining conditions of social life. The intertwined paths give shape to spaces. In that respect, pedestrian movements form one of those "real systems whose existence in fact makes up the city" – they are not "localised", it is rather that they are spatialised (DeCerteau, 1984, pp. 96–97). The operation of walking, wandering or "window shopping", i.e. the activities of passers by, is transformed into points that draw a totalising and reversible line on the map. The trace left behind is substituted for the practise. (...) Space is a practised place (DeCerteau, 1984, p. 97).

Hynek et al. (2011, p. 51) discusses the spatiality concept, in a similar fashion to Siwek (2011, p. 57), and claims spatiality is the quality related to space, indicating the sufficiency of space for the localisation of objects and for human activities. It is very exciting to observe the absolute space of streets, buildings, gardens or parks pulsating with social processes which create the relativity of such space, i.e. its spatiality (Hynek et al., 2011, p. 61). The question of the smallest geographical spatiality should remain open as it is possible to start with the proper body, flat, etc. (Hynek, 2011, p.22).

Place incorporates the way an individual both looks at the world, understands and interprets it. Place is the concept which provides individuals with understanding and learning about their surroundings, about other people and himself/herself. The individual can learn and educate himself/herself through the place which s/he inhabits, and place is becoming imprinted in his/her imagery and experiences (Vávra, 2010, p. 473). Place matters and its importance is multifaceted (Castree, 2003, p. 181). Place is among the most complex of geographical ideas and according to Castree (2003, p. 5) it has three meanings in Human Geography: (i) a point on the Earth's surface; (ii) the locus of individual and group identity; and (iii) the scale of everyday life. In comparison, Relph (1976, p. 45) claims that the human is not just an address in a register or a point on the map. The very identity is the basic characteristic of the individual, which emerges from his experience with places that influence him. The proper identity of a place is not only important but also the very identity linked to the place for each individual or group. Keith and Pile (1993) think cultural geographers consider place as something which forms an individual as well as group identity; place is directly reflected in the character of people. Massey (2005), however, thinks we should not be finding the roots of peoples' identity, but rather their life routes. In this way, it is possible to know how these "local" identities were created following the ways people identified with several "non-local" influences. There are also the issues of institutionalisation and community construction (Brace et al., 2006) and placed identities, together with notions of sacredness and the private dimensions of faith.

Close relations and the familiarity which is part of the knowledge of concrete places, is contained in common and personal experiences with places. The relation is mutual and creates roots in places. Such familiarity is not only the detailed knowledge of place but also the sense of deep relation or (spiritual) care for this place (Relph, 1976, p. 37); see also, Tuan (1977), Vávra (2010), and for a more recent study on religion and place, Hopkins et al. (2013) who focussed in particular on the role of place and the 'co-production of religion and place'. The relation which lies in the intimate knowledge of the place is created through long-term experience with the place. This relation is created in time and it is the base of our embeddedness in the place: to have roots in the place means to have a secure point from where we can observe the world and go beyond it, and to have such a secure point means to be embedded in the place (Relph, 1976, p. 37).

2.3 Sacred spaces

Sacred space is that of archaic religious experience: it is continuously differentiated and replete with symbols, sacred centres and meaningful objects (Relph, 1976, p. 15) and it is very characteristic of pilgrimage places, for example. For the religious person, the experience of such space is primordial, equivalent perhaps to an experience of the founding of the world, and it follows that the making of sacred objects and sacred buildings (and in some cultures that includes virtually all buildings) is not a task to be undertaken lightly, but involves a profound and total commitment (Relph, 1976, p. 15). Nevertheless, there are also personal places existing, and sometimes they even exceed "public" places of faith. Some places have purely personal meanings – the house where the individual grew up, a room where the prayer takes place, etc. (for the importance of personal places, see Raglan, 1964; Relph, 1976; Smith, 2008; Novotný, 2018).

Sacred space represents a part of the Earth's surface which is considered worthy to be revered by individuals or groups. Such spaces can be sharply delimited from the non-sacred or profane outside world. In some senses, sacred space does not exist, but it has the value of "sacredness" assigned to it, people establish its limits and characteristics related to their culture, experiences and aims (Park, 1994, p. 250). The sacred is nothing other than the construct of meanings which humanity objectifies as a power that is radically different from itself, and it projects itself on reality to escape the anxiety of being engulfed by chaos (Hervieu-Léger, 2000, p. 72).

An issue for the use of sacral spaces and the creation of more personal places is related to the meaning of so-called secularisation. The essence of the secularisation thesis lies in the precondition that modernisation processes (industrialisation, urbanisation, educational change processes, concepts of rationality, etc.) are automatically connected with a decrease of the meaning of religion (Nešpor, 2010, p. 17). Berger (1967) defines secularisation as the process by which sectors of society and culture are removed from the domination of religious institutions and symbols. The process and the proper term "secularisation" are discussed from many points of view (Bruce, 2002; Dobbelaere, 1993; Davie, 2002; Hervieu-Léger, 2000; Martin, 2005). The following circumstances are usually mentioned as 'proof': decreased participation in religious life (masses, religious feasts, confessions, etc.); the decrease of complex orthodox thoughts and practices; the reduced support for religious organisations, etc. (Václavík, 2010, p. 31).

Current defenders of the secularisation thesis are, for example, Steve Bruce (2002, 2003, 2011) or Karl Dobbelaere (1993, 1998, 2002), while other renowned authors are against the thesis: Dave Martin (2005), Grace Davie (1994, 2000, 2002) or Daniele Hervieu-Léger (1996, 2000). The latter three authors describe various

forms of religious revival (re-sacralisation), such as the representations of variable non-church spirituality, or the new roles of churches in society. A relatively similar point of view is seen in the concept of post-secularism, originally introduced by Habermas (2006) and later developed also through the religious landscape concept, for example by Knippenberg (2005), Henkel (2014), Havlíček (2014) or Havlíček and Klingorová (2017), and also in Great Britain where it is related to ethical issues and social problems in the cities (Glasze and Schmitt, 2018). Religious landscape studies focused more concretely on churches in the United States are presented by Zelinsky (2001), studies of house churches in Singapore by Kong (2002), and for religious landscapes in Peru, see Olson in Hopkins et al. (2013). Different treatments of both agreement and criticism of post-secularism and post-secularity terms are reflected recently in the work by Glasze and Schmitt (2018).

Another related term, the privatisation of religious life, indicates the shift from Church religiosity towards a more individual (rather than collective) manner of living experiences, and it also can mean a shift to non-Church spaces (nature, home, individual mental abstraction, etc.), where religiosity can be realised. According to Bruce (2002, p. 20), the privatisation of religion generally causes the removal of social support: individuals do not proclaim themselves as members of a certain community. Such social support is fundamental to the strengthening of the faith and, if missing, then the maintenance of certain lifestyles (in accordance with determined Church rules) becomes very difficult. Šiler (2017, p. 125) notes a growing trend in the Czech environment: faith or spirituality moves towards the privacy of the home, intimacy, individual isolation; the Churches fail in their efforts of offering services in adequate highly personalised form, focused on the "user" (a potential believer). This is the reason why society seems to become secularised and seen to lose religion for many observers.

Yet another term – the "spiritual market or marketplace" – is often discussed (Davie, 2000; Nešpor, 2010; Václavík, 2010). It denotes that the religious systems cease to have sharp frontiers and become fuzzy idea systems, even in such a dogmatic system as Christianity through the interpretation of the main denominations (Václavík, 2010, p. 159). The city is a specific territory from the point of view of the religious market. According to Bartolini et al. (2017, p. 342), far from being the first place and foremost space where religion is expelled from modern social life, or exists in small islands, the city is rather a battlefield between good and evil. Modern cities also happily accommodate evangelical Christian movements, as well as the political Christian Right (Hackworth, 2012; Hackworth and Gullikson, 2013; Hackworth and Stein, 2012). The city becomes a kind of spiritual battlefield.

Tuan (1978) claims that the real meaning of the "sacred" goes beyond the boundary of a stereotype image of temples and shrines because, at an experiential level, the sacred phenomena are those which stand out from common places and routines. Rather, emphasis is placed on properties like remoteness, otherworldliness, orderliness and complexity, in defining what is sacred. "Otherworldliness" relates as well to issues of post-mortem spaces: similarly, Lužný and Nešpor (2010) or Park (1994) utilise the concepts of "other world" or "other averted world", which do not consist just of the existence of a post-mortem space but are rather a whole realm or dimension or spaces ruled by evil creatures, which sometimes are designated as demons.

2.4 Post-mortem spaces: known and unknown worlds

In this section, I discuss two primary issues: a) the imagery of post-mortem spaces; and b) occult forces and practices connected with designated places. Religion has determined dogmatic bases which deal with the topic of the afterlife while, at the same time, the capacity of explaining difficult transcendental questions (the meaning of the death, etc.) can attract potential believers. The primary aim in this part of the study was to examine the imagery of current post-mortem spaces and the spaces of the so-called "other averted world" (of evil spirits). A secondary aim was to compare such imagery with Church dogma and, eventually, identify any differences or new trends in the frame of the imageries of young believers. This follows also the trend to re-install youth geographies since the 1990s, according to Hopkins (2007, p. 163) who claims voices about the lived experiences of young people are usually silenced, often unheard and frequently distorted. Equally, we should mention the studies on urban youth (Van Blerk and Horschelmann, 2011) or the religious transitions of young people into adulthood (Hopkins et al., 2015), which also use a qualitative research approach incorporating interviews and focus groups.

Faith in the afterlife is a central point for the Christian tradition. The death and after-death fate of humans has a central role in Christianity, which used to be characterised as the religion of salvation. Christian teaching promises the resurrection of the body and salvation of the soul for the believers. According to the believers, alternative spiritual worlds exist during our terrestrial life and it is possible to be in contact with these worlds. Some results also indicate the importance of places of occult practices (eventually inhabited by evil forces), and Christians are usually strongly afraid of these practices. The fear of alternative spiritual practices is based on the conviction that whole spiritual worlds exists, parallel to the material world, which is divided in good and evil (Lužný and Nešpor, 2008, p. 55). The so-called occult is calling to humans, and according to Dixon (2007, p. 719) it has never stopped 'ringing' on the exchanges between science and technology, urging a lineage of verification, empirical evidence, invention and proofs (see also Ronell, 1991).

Given the existence of the above-mentioned practices, instead of the question of who is winning the war between faith in God and faith in science, according to Bartolini et al. (2017), there is (at the very least) another question: how different occult, divine, otherworldly, superstitious, supernatural, paranormal and spiritual (etc.) ideas (from whatever source) continue to thrive and weave their ways through modernity. Indeed, for Partridge (2005), modern culture is in fact better described as occulture – which is readily witnessed in all popular cultural forms, from music to cinema, from literature to the visual arts (Bartolini et al., 2017, p. 346). As we continue into the twenty-first century, however, the authoritative status of science looks far from certain (Dixon 2007, p. 730). The occult exists in an epistemic 'purgatory' (Dixon 2007, p. 731), as a sublime presence of something beyond perception and beyond imagining, the contemplation of which unsettles our sense of what it is to be human (Dixon 2007, p. 731).

I believe that for these issues, the geographical aspects or rather fields of inquiry, to explore, as proposed by Park (1994) or Dixon (2007), deserve more attention. Thus, the above-mentioned reconstruction of attitudes towards death is reflected in this work in the sense of studying the imagery of post-mortem spaces and the geography of such spaces.

3. Methodology

The principal aim of this section is to present particular phases of the research project, including the pilot study in the Seventh-day Adventist Church in Brno Lesná district, the field study in Přerov region in May of 2017, and generally the long-term research on the spatial imagery of young believers in Brno (2014–2017).

The research project in its final phase was transferred to the industrial city of Ústí nad Labem, to validate selected research strategies in another (post-) industrial city (similar to Přerov), and to continue also with the forthcoming research work there: see for example the study of sacral landscapes in Ústecký Region (Bobr and Novotný, 2018) and in both South Moravian and Ústecký Regions (Novotný et al., 2018).

3.1 Grounded Theory

There was a "problem" in the beginning of this research inquiry with regard to the processes of inductive research (Strauss and Corbin, 1990; Hendl, 2005; Disman, 2008), but later data were collected via participant observation procedures and semi-structured interviews (Kvale, 1996; Cloke et al., 2004), following Grounded Theory methods as described by Strauss and Corbin (1990), the authors who developed the original concepts of Barney Glaser and Anselm Strauss (1967). The final aim of such an inquiry is the formulation of new hypotheses, new understandings and the creation of theory (Disman, 2008, p. 286). If we simplify it, the structure of the selected Grounded Theory approach consists in:

1. collection of the data, aiming to establish the codes continuously, as the research continues;
2. coding the materials with the aim of creating the basic categories, i.e. variables that could constitute the future theory; and
3. construction of the theory as a set of statements about the relation between categories/variables.

These stages overlap in a mutual fashion and each is realised with respect to other stages (Švaříček and Šeďová, 2007, p. 87).

Grounded Theory is inductively derived from the exploration of the relevant phenomena which are represented by the theory. Thus, the theory is revealed, created and provisionally verified by a systematic evaluation of the data about the explored phenomena and by analysis of these data. In this study, then, the "spaces and places of the faith" are examined, more precisely, their utilisation and perception by mostly young believers. This approach means that the field data and their continuing analysis and re-analysis and relevance to the emerging theory, are mutually complementary. We do not start with a theory which is verified a posteriori: we rather start with some 'determined' themes for the study and let the important facts emerge (Strauss and Corbin, 1990, p. 14). Grounded Theory is like a proposal for how to seek some specific theory which concerns the delimited population, settings and/or time in a certain manner (Hendl, 2005, p. 243). When starting with the determined theme/field of study ("Spaces and places of faith in an allegedly highly secularised society") and with the research problem ("Where and what are the spaces and places of faith of young believers in this period of so-called secularism?"), the aim was to evaluate religiosity in space from the point of view of the believers, i.e. to represent what the believers think and how they perceive their surroundings in relation to the faith, where the believers gather, etc., with a focus on urban space (Brno, Přerov, and Ústí nad Labem).

3.2 Current research processes

In summary, the present text is based on a four-year research project which started with a pilot ethnographic study, conducted between February and June 2014 in the Seventh Day Adventist (CASD) mission in Brno, Lesná district. After finishing the participant observations, relevant communication partners were selected and approached. The contacts were mainly provided by respondent-driven sampling (Cloke et al., 2004, p. 156), which can be realised with the help of a gatekeeper, the preliminary contact person with the researcher. The gatekeeper usually helps strongly with "opening the door" to a selected community, and the main advantage of this method is the opportunity to gain contact and recommendations to other people who are willing to speak openly or provide relevant information which is needed for the researcher.

In the period 2014–2016, semi-structured interviews with Brno members of the Adventist Church took place. The interview with the preacher provided the grounds for expressing the basic research issues, and the decision to concentrate on young believers (age 20–30 years) was made. One of the basic questions in the inquiry was why a young person decides to join the faith and how it is expressed in space. It also appeared to be useful to study not only members of CASD but to include young representatives of other Churches as well.

From June 2016, communication partners were selected from the specific category of persons in the approximate age group of 20–30, when – as was verified in the pilot study – a complicated spiritual seeking often takes place and eventually a solid decision for a certain religious/spiritual orientation is made. This age can also be crucial from the point of view of deciding future aims in life, e.g. starting a family, the birth of a child, beginning employment, building a career, the creation of a relatively permanent worldview and values, or an expression of one's own religiosity, etc. In Brno, 12 men and 12 women in the age group 18–30 participated, 7 men and 5 women in Přerov, 2 men and 2 women in Ústí nad Labem and its surroundings. The average age of communication partners in our designated category of "young believers" (age 20–30) was 24.9 in the explored regions; in the case of all respondents from all regions the average age was 33.3.

The first phase of the original research was completed in September 2016, and after this date mainly older communication partners were approached to gain more opinions and to deepen the recent issues and to clarify new questions that had emerged from the previous inquiry. More recently in the Ústecký Region (since 2018), perceptions of the sacral and spiritual elements of the landscape were studied (Bobr and Novotný, 2018). As generally the case in long-term research projects, censuses and the commentaries of various authors (Heřmanová and Chromý, 2009; ČSÚ, 2014; and others), but also from the responses of selected communication partners, it was found that the Ústecký Region is one of the less religious regions in the Czech Republic. Research on religiosity in this region then offers tempting opportunities for future study.

In the frame of research on "spaces and places of the faith", the main focus was on the Christians. With certain intentions (potentially opinions of opposition), members

of the Roman-Catholic Church, the most traditional and numerous Church in the country, were selected, versus members of Protestant or conservative Christian bodies, like the above-mentioned Adventist Church or other Protestant and evangelical Churches, which are opposed in a specific manner towards the Catholic Church (Novotný, 2018). The opinions of representatives of so-called alternative religiosities are discussed for comparison. Further research into the phenomenon of alternative religiosity is needed, thus it is rather marginal for this project.

4. Results and discussion

The results represent every-day and regular activities related to the faith. Spaces linked to these findings are presented in four main thematic groups (categories) which emerged from the inductive research using Grounded Theory: (i) spaces of everydayness; (ii) spaces of more evangelisation (broadening of the faith); (iii) personal places of faith; and (iv) imagined post-mortem spaces and spaces of the "other world" occult phenomena.

4.1 Spaces of everydayness and regular activities

Visits to church and other sacral spaces are only occasionally related to the everydayness of faith in the case of young believers: Everydayness lies rather in a close relation with God. This relation can consist of regular talk or permanent consciousness of God's presence. Prayer is not necessarily an everyday issue. Equally, a visit to the church does not happen necessarily every week. In sum, there is a trend to deinstitutionalisation among young Czech believers, in comparison to older believers, who maintain regular or even everyday habits (church visits, participation in Church community life which is often linked with the importance of such a community for older believers, etc.).

Young believers tend to perceive a certain negative "supervision of the community" over an individual, generally in closer communities of believers in rural areas. The anonymity of the city is given preference and it is seen mainly in the case of students who moved to Brno from its surrounding rural regions. Eventually, such participants study and work in Brno while still living at home (in rather rural areas) and have the comparison between both modes of experiencing the faith in different settings. The most expressive example was the case of Bára (23), whose father serves as a deacon in a small municipality some 30 km from Brno, where Bára perceives the supervision of the community as very strong and restrictive.

An overwhelming proportion of believers consider mornings as crucial moments linked with the faith. Participants who do not like getting up in the morning postpone their daily time preferences dedicated to the faith to the evening hours (practically, always the favourite day time for the believers). The evening is proper for contemplation, and recapitulation of the previous day. Religious experience then necessarily differs from believers with preference for the morning: those persons perceive awakening as "a new life", and they utilise the morning time to be "put in the mood" for the upcoming day, etc.

Most young believers were not able to define "habit or repeated activities": they designate activities like prayer or visiting church/mission as natural or spontaneous, and not repeated or habit-creating because these terms (habit, repetition, etc.) are linked rather with negative perceptions. Older believers do not have a problem with these terms.

It seems that the faith does (or not) combine with work-life. It is possible to "not think of God all day" due to the surplus tasks of labour; however, then God could be even more recalled through "ordinary things" after work, it can be a blooming flower or a certain scene in the landscape (see the importance of time-space configuration, e.g. Catholic believer Soňa from Ústí nad Labem). Students without regular employment often talk with God during the entire day.

4.2 Spaces of evangelisation

Although young Catholics recognise several evangelisation events (i.e. events dedicated to spreading the faith), at the same time they consider communication between friends as the best approach to evangelisation. Young believers do not want to do 'street evangelisation', they even see it as very negative for the case of established Churches and movements (Hare Krishna disciples, the stalls of Mormons and Jehovah's Witnesses), which are approaching potential believers in the street or public spaces. Older believers often feel frustration regarding the effectiveness of any evangelisation efforts.

The visibility of the faith in urban space is naturally perceived more by those Christians who seek spaces of the faith. The visibility of any Church was often linked with current Christian personalities (Pope Francis, or popular Czech clergymen like Tomáš Halík or Marek Orko Vácha), who influence (young) believers in specific spaces (church, mission, Biskupské High School in Brno) or in virtual space (transmissions of preaching via the Internet, even including mental abstractions created by the reading books of these authors). The possibility of a mass meeting with the Pope has a strong importance for young Catholics.

A large "trust" in God (close friendly relationship) – this is how a large part of the believers in this research described their faith attitude. Older believers even represent this attitude in such terms, i.e. they elicit the word "faith" and speak about "trust in God". On the other hand, trust in local Church representatives used to be volatile: sometimes the priest was an unquestionable authority (often linked to the capacity for interesting and actual preaching), but at other times the believers did not have respect for the priest or preacher. This was particularly the case in municipalities where the priests were installed from a distant region or even a foreign state, usually from Poland. Polish priests working in the Czech Republic are usually perceived negatively by believers in this research project, mainly because of their incapacity to become accustomed to the local community or their lack in providing interesting preaching. An exception in this project was the perception of the Roman Catholic priest Jan Kornek (also born in Poland), who incited a religious resurgence in the Dub nad Moravou municipality near Přerov.

Believers in the Czech Churches, as well as representatives of current spiritual waves, rely on the willingness of individuals to approach the church/mission/meditation centre. This interest is intentionally stimulated by moderate forms of evangelisation, such as bill posting in urban space. With the aim of broadening the faith or spiritual learning, several courses/biblical classes/meditations/lectures are held. On the other hand, some current believers (e.g. the Seventh Day Adventists in Přerov) do not trust the effectiveness of posters and flyers and emphasise the importance of personal communication.

4.3 Personal places of faith

Although young believers typically speak about the omnipresence of God, at the same time they identify their own "places of faith". These places are created in personal

space (their own room, bed, a specific place during a lonely walk in nature, etc.). These places can have a certain regularity on a daily or annual level. By the latter, we mean for example places of pilgrimage (see the often-mentioned Hostýn hill or, more precisely, personal perceptions of the importance of this commonly known Christian place), as well as the church in their native region linked to the Advent period or Easter feasts.

Personal places of faith can also be linked with everyday religious practice. Bed can become an "everyday place of resurrection", where the prayer, destined mainly for the individual to be "put in the mood" for the upcoming day, takes place. Evening recapitulation is often linked with a personal place of the faith, as in the case of Czechoslovak Church member Jiří (46) (with his act of contemplating under the nocturnal sky), Klára (23) (a remote place in Ore Mountain, or a later similar place in Podkrkonoší Region), or simply the bed before sleep in the case of many young believers. This evening "putting in the calm" was called "meditation", even by many Christians: it confirms the trend of an increasing fusion between Christian and "Eastern" imagery about the faith among young Christians. Places which incite religious experiences were accidentally found: forest chapels or crosses – see for example Jirka (23) and his experience in the forest of the St. Anthony chapel near Brno, crosses and God's tortures in the landscape from the point of view of Jarin (originally from the Zlínský Region but who studied in Brno), or the pilgrimage place Skoky accidentally found in the chapel in Ore Mountain, both also mentioned by communication partner Soňa (36) from Ústí nad Labem.

It is not only the pilgrimages which are fatiguing to several degrees, journeys through the landscape have also their own religious meaning for the believers. Such journeys can serve for contemplation. The relation of believers towards pilgrimage places is problematical. These places are naturally linked only with Catholicism, while other Christian churches do not have pilgrimage places and the Catholic concept of pilgrimage place is sometimes even criticised by representatives of other churches. Older Catholics positively perceive pilgrimage places, mostly for their link with the traditional faith and with past generations of believers; however, young believers rather evaluate these places via experiences incited by the actual places. Pilgrimage places can be designated as too decorative, then criticised with a refusal to visit (often mentioned was the Vatican, sometimes Hostýn because of the souvenir stalls, etc.). Some Catholic churches are also rejected for any visits due to excessive decorativeness, even by proper Catholics (again mostly young ones). Although some young Catholics consider churches as their "places of faith", these are not necessarily the most important ones.

Older believers are capable of interpreting very well their own "places of the faith", and with much more detail than young believers usually do. This can be explained by long-term life experiences, long-time routine or regular repeating of favourite religious practices and habits.

The spiritual experience is specific and, at the same time, an important fact. According to the opinions of Christians and representatives of alternative spiritual currents, people usually feel or seek spirituality. "Seekers" dedicate themselves to experimentation with spiritual practices (or, worse, occult practices), and eventually they deepen their interest in such practices; sometimes the spiritual seeking is consulted with a priest who used to be perceived as a spiritual authority, even by non-believing or seeking persons. In a broader context than the personal frame (e.g. a village community), the re-sacralisation can be triggered by the local priest (Dub nad Moravou).

Places can "influence" – they are "extraordinary", they have "its spirit", they cause "inner experience". Experience means a certain transcendence, an immediate link of the individual with God. It is possible to reach the experience in a pilgrimage place, and the Christian tradition and history of the place can serve as added value, but in the same place and at the same time "the commercial side" linked with pilgrimage places is seen as problematical or disturbing. The experience can be given by the intersection of a specific time and space (e.g. in the words of female respondents Soňa and Klára, both from Ústí). Living the spiritual experience in a certain place, however, does not mean that the experience can be regularly repeated in the same place. These findings are in accordance with Tuan's and Relph's concepts of place, as well as with some of the above-mentioned other authors (Castree, 2003; Thrift, 2003; Vávra, 2010; Gibas, 2014).

Older believers perceive and honour places linked with tradition and the personalities of a given Church, while younger ones rather intuitively seek personal places, although this does not mean that older believers do not have long-term personal places of their faith. In addition, places with "the tradition" are marginal for young believers because they evoke institutionalisation, which is seen as largely bad for young believers. Older believers do have personal places of faith and they are able to thoroughly discuss them due to their long-term experiences.

The so-called "spiritualists" also have personal ties to places, mostly in nature. Nevertheless, relations to buildings (also often related to nature) exist too: "places can influence", e.g. Hostýn. Sometimes a determined place means home (homeland), at other times it represents seeking and finding places of calm related to the experience of nature.

4.4 Post-mortem spaces and the "averted other world"

Post-mortem spaces are imagined by practically every believer in this research. Women usually think much more deeply about the afterlife and are often inclined to an explanation through the concept of reincarnation. This concept in the present is often acceptable even for many young Catholics, or, more precisely, several young Catholics participating in this research considered reincarnation as the best explanation of the afterlife, but this is totally opposite to Catholic Church dogma. Older believers, both men and women, do not identify themselves with reincarnation, nor with other "Eastern practices".

If the believers imagine the afterlife as Heaven, this idea brings them feelings of calm and "hope" (this word was mentioned by representatives of various Churches), but the imagery of Heaven differs considerably. Young women (aged 20–30) often consider Heaven as a certain "waiting room", a temporary space from where the soul can return to Earth. At other times, Heaven is imagined as a space 'identical' to terrestrial life, but where violence, pain or other sufferings do not exist, and eventually it is a space of gathering with close persons. Men usually do not have a specific idea of Heaven, considering such ideas as practically unrealisable for human beings, and usually do not think deeply about this issue. Male participants in this research commonly suppose that Heaven is a perfect absolute space and, in comparison to women, do not speculate about its concrete semblance.

Hell, if respondents believed at all in its existence, is mostly imagined as a (painful) state of mind. It can consist of a permanent mental sequence of the worst life-facts: negative actions caused by the individual in their previous life. Believers are absolutely convinced about the existence of a parallel "second averted world": it is in total agreement with the afore-mentioned literature (Lužný and Nešpor, 2008, etc.). This second world is driven by Satan, whose manifestations are relatively clearly identifiable in everyday life for many believers. They document it in several cases from their own lives or in many overheard stories and experiences of close persons. Certain spaces and places of occult practices are perceived very negatively by believers (e.g. pagan sacrifice places, witchcraft shops or spaces of Satanist rites), and often these places are considered outside the protection of God.

The themes of the imagery of post-mortem spaces and the related afterlife appeared to develop very strongly in the frame of the research interviews and could be potentially fruitful from a geographical point of view. Moreover, Geography has not studied this issue in much detail up to now, although the theme contains considerable spatial aspects.

5. Conclusions

The research on spaces and places of Czech believers is closed for now: the planned phase of the research has been concluded. Hendl (2005, p. 243) claims that Grounded Theory is a set of suggestions to seek specific theory which concerns the delimited population in certain ways, in different settings and/or time periods. In our case, the chosen way was inductive qualitative research and the population consisted of believers in selected locations, offering comparisons between a larger urban complex with a relatively colourful religious scene (Brno) and (post-) industrial cities and their surroundings, where religiosity has been very low for a long time, mainly in the core areas (Přerov, Ústí nad Labem). Young believers in Brno with an approximate age between 20 and 30 years, were the original group subject to inquiry. In Přerov older believers formed the core group, while in Ústí nad Labem older ones also formed the majority. In the later phase (2017–2018), representation of the age group was not achieved in a practical sense, nor the locality of the research given the representation of the research problem. The settings or environment of the research was first the urban space of Brno and its close surroundings, including respondents from relatively close districts with high religiosity within the Czech Republic (Břeclav, Kroměříž, Zlín). There were however always strong ties to Brno, in keeping with the criterion of at least 5-year regular activity in the city. In subsequent stages, the urban space of Přerov and its rural surroundings was included, and in the last phase the urban space of Ústí nad Labem and its close neighbourhoods. The designated time period consisted of "the present", which has been allegedly strongly affected by the secularisation phenomenon.

Our most important result was the documentation of a shift from public spaces to personal places of faith, mostly for younger believers, which represents a strong trend to de-institutionalisation and de-traditionalisation of the faith. Although older believers do not fit into this trend, they perceive this tendency in actions and activities in their close surroundings, including their own children and relatives in the designated age group. The faith is spatialised: equally, as the space of the faith, the faith is created, it is happening, it is constructed and reconstructed. Grounded Theory is represented here by a new look at the so-called secularisation process, which in the context of current Czech believers (mainly younger ones) means a long-term, not only physical but equally mental, shift in preference for the geographical spaces and places which were utilised by Czech believers for decades.

This shift manifests itself in many ways and four main pathways correspond to the categories revealed by this research. Church communities and the gathering of believers take place in the everyday or, more precisely, on a regular basis, in concordance with the concepts of space, spatiality and everyday rhythms (DeCerteau, 1984; Lefebvre, 1991; Hynek, 2011). With respect to the evangelisation spaces, it is possible to capture a decreasing interest of young believers in the evangelisation in public spaces, and again it is rather a shift into privacy, towards personal places and to seclusion. The above-mentioned trend manifests itself also in this issue. As well, there has been an increase in the refusal of evangelical activities of other Churches in the public space: this is recognisable again more for young believers. Older Church members rather comment on their frustration from long-term relatively unsuccessful evangelisation. They usually do not comment on the evangelical activities of other groups, but they are able (if asked) to offer an explanation why certain groups (Jehovah's Witnesses, Buddhists…) are successful in gaining new members. The older believers often prefer "personal ways" of evangelisation rather than manifestations in public spaces.

With respect to secularisation, it was the principal thread of the research. With our long-term study of the spaces and places of faith, we present some evidence of secularisation in the Czech context, knowing that secularisation is an ambiguous term which, based on our years of study, we do not evaluate as the decrease of believers and religious manifestations but rather a shift from the more public to the more personal. It does not mean personal places would not exist before nor spaces of gathering would end to exist in the present. It means mostly a shift in the attitudes mainly of young believers, who are a key group for the future development of the Churches and eventually for the maintenance of Christianity in the Czech Republic, especially with respect to how they will influence and educate future generations of believers.

Post-mortem spaces represent a topic which was developed strongly during the research. I had started out with a rather personal interest in knowing how respondents might judge this issue, mostly those from Catholic surroundings: if the general and dogmatic ideas of Churches are valid also in their everyday realities, and how the respondents deal with the theme of death and the afterlife. Later, this issue gained a strong spatial aspect: post-mortem spaces were considerably imagined and regularly dealt with by communication partners (women rather than men). Other spaces were represented by the existence of otherworldly beings, the ghosts of deceased people, demons and other beings which can harm the individual. The places linked with these manifestations were discussed: places with "negative energy" (pagan sacrifice places, designated cemeteries, places of negative events like a murder or Satanist rites, for examples). In the case of post-mortem spaces, women in particular tend to disagree with Church dogma, and they often prefer the reincarnation concept and often incline to ideas of Eastern religions, eventually to the fusion of non-Christian esotericism with the ideas

of Christianity. The ideas of the Purgatory and Hell are basically marginalised, as the idea of Hell is often imagined as an unpleasant and even painful state of mind. Research results were compared with the literature about the theme (Tichý and Vávra, 2012; Nešporová, 2013; Bartolini et al., 2017). It appears to be beneficial for the future to continue researching this issue, which relates Geography to Psychology and includes, perhaps, a controversy linked with the uncovering of taboo topics.

In this work, the possibilities of a geographical study of current religiosity in Czech society were verified, and it was completed using inductive qualitative research. This text has aspired mainly for a better understanding of the construction and reconstruction of the spaces and places of faith of Czech believers.

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Postscript

This article is published in its original version, as submitted. As such, it has not been subject to the author's corrections after review, as the author suddenly died during the editorial processing. Due to the originality of the research and results, however, the Editorial Board decided to publish the article. Gustav Novotný (1987–2019) was an Assistant Professor in the Department of Geography, J. E. Purkyně University in Ústí nad Labem. He obtained master's degrees in Spanish Language and Literature (2012), and in Social Geography and Regional Development (2013) from Masaryk University in Brno, where he continued to study and successfully defend his PhD. thesis on "Faith spaces and places of Czech believers" (2018). Along with unrelenting interests in qualitative research of alternative religious movements, he was an excellent teacher in courses spreading across political and regional geography and theory of geography, and a great supervisor of bachelor and diploma theses. We will remember him as unpretentious, diligent colleague always open to cultivated discussion, a man of many interests, and a good friend of ours.

Associate Professor Pavel Raška

Fig. 6: The coal-fuelled power plant in the town of Rovinari is one of the main air polluters in Gorj county. (Photo: R.-M. Cocheci)

Fig. 7: Open-pit mining of lignite in the Motru-Rovinari basin is considered to be one of the economic activities with the greatest environmental impact in the country. (Photo: R.-M. Cocheci)

Illustrations related to the paper by R.-M. Cocheci et al.

MORAVIAN GEOGRAPHICAL REPORTS

Aims and scope

Moravian Geographical Reports [MGR] is an international, fully peer-reviewed journal, which has been published in English continuously since 1993 by the The Czech Academy of Sciences, Institute of Geonics through its Department of Environmental Geography. The journal followed the traditions of the Reports of the Institute of Geography of the Czechoslovak Academy of Sciences, which was published from 1963 to 1992.

The MGR journal has been indexed in the SCOPUS database since 1993. In 2012, MGR was selected for coverage in the WEB OF SCIENCE (Thomson Reuters/Clarivate Analytics) products and customs information services. Beginning with Volume 19 (2011), this publication is being indexed and abstracted in the Social Science Citation Index ®, Current Contents Connect ®, Journal Citation Reports / Social Science Edition ®.

As a general purpose journal, it receives and evaluates articles contributed by both Human and Physical Geographers, as well as by other researchers who specialize in related disciplines, including the geosciences and geo-ecology, and the human sciences (sociology, urban studies, etc.). The journal has a distinct regional orientation, broadly for countries in Europe. The title of the journal celebrates its origins in the historic lands of Moravia in the eastern half of the Czech Republic.

The Moravian Geographical Reports aims at presenting original and relevant research on topics responding to the role of 'regions' and 'localities' in a globalized society, given the geographic and temporal scales at which they are evaluated.

Several inter-related questions are stressed:

- the problems of regional economies and societies, especially over time;
- societies and societal change in urban or rural contexts;
- regional perspectives on the influence of human activities on landscapes and environments;
- the relationships between localities and macro-economic structures in rapidly changing socio-political and environmental conditions;
- environmental impacts of technical processes on bio-physical landscapes; and
- physical-geographic processes in landscape evolution, including the evaluation of hazards such as floods, landslides, etc.

Theoretical questions in the broad discipline of Geography are also addressed, especially the relations between Physical and Human Geography in their regional and temporal dimensions.

Types of papers

The journal, Moravian Geographical Reports, publishes the following types of papers:

(1) Original scientific paper: the backbone of individual journal issues. These contributions from geography and regionally-oriented results of empirical research in various disciplines, normally have theoretical and methodological sections and must be anchored in the international literature. We recommend following the classical structure of a research paper: introduction, including objectives; theoretical and methodological bases for the work; empirical elaboration of the project; evaluation of results and discussion; conclusions and references. With the exception of purely theoretical papers, each contribution should contain colour graphic enclosures such as maps, charts, diagrams, photographs, etc. Some of the photographs may be placed on the second, third or fourth cover pages of the journal. For papers on regional issues, a simple map indicating the geographical location of the study region should be provided. Any grant(s) received to support the research work should be acknowledged. Major scientific papers include an Abstract (up to 200 words) and 3 to 6 keywords. The length of the text should be in the range of 6,000 – 8,000 words (the word count does not include the abstract, tables, figures, and references), plus a maximum of 3 pages of enclosures (tables, figures). The number of graphic enclosures can be increased by one page provided the text is shortened by 500 words below the maximum allowable length (per graphic page). All scientific papers are subject to the peer-review process by at least two independent reviewers appointed by the Editorial Board.

(2) Scientific communications are published to inform the public of continuing research projects, scientific hypotheses or findings. This section is also used for scientific discussions that contest or refine scientific opinions, including viewpoints and/or comments that critique recently- published papers. The maximum text length for these scientific communications is 4,000 words. Some contributions may be reviewed at the discretion of the Editorial Board.

(3) Moravian Geographical Reports also publishes Invited reviews of major monographs from geography and related disciplines published as books or atlases. Reviews are supplied exclusively on request from the Editorial board. The review must contain a complete citation of the reviewed work and its maximum text length is 2,000 words. Graphics are not expected for the reviews section.

For a detailed description of the types of papers, preparation of submissions and review process see the Instructions for Authors on this webpage: http://www.geonika.cz/EN/research/MGR_instructAuthors.pdf

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