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# SPATIO-TEMPORAL CHANGES IN RURAL SETTLEMENTS: A CASE STUDY OF THE BOŠÁCKA DOLINA VALLEY

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**Spatio-temporal changes in rural settlements: A case study of the Bošácka dolina valley**

The purpose of this article is to analyse the transformation of rural settlements, including an approximation of the number of inhabitants, through a detailed analysis of the built-up areas – buildings over a time horizon of approximately 170 years in the The Bošácka dolina valley (White Carpathians, Western Slovakia). The analysis includes a detailed survey of the functional use of the housing stock in a selected part of the studied region. The results proved a growing concentration of settlements in the studied area. At the same time, they confirmed the process of the functional transformation of areas with dispersed settlements, where residential buildings are converted into recreation facilities (cottages) or seasonal dwellings or remain uninhabited. This process exhibits spatial heterogeneity within the studied area, predominantly impacting marginal regions characterized by dispersed settlements. The functional transformation of buildings and depopulation were also confirmed by the data on the number of inhabitants, where a dynamic decrease in the number of inhabitants can be seen, especially in the extra-village areas of the investigated municipalities. The study findings indicate the loss of the original function of the dispersed settlement, which is spatially most evident in marginal areas and indicates the disappearance of dispersed settlements.

**Key words:** dispersed settlement, buildings, transformation, population, Bošácka dolina valley, Slovakia

## INTRODUCTION

The concept of a settlement is among the central concepts of geography, and its definition is among the "deliberately" more complex, mainly because the term settlement can be understood as any place on earth where people live (long-term); (Nuissl 2018). Settlements at the same time, "as relatively closed formations, developing in space, represent a chronicle of human history in a cultural landscape" (Lauko 1999, p. 269). A special type of settlement in Slovakia is a dispersed settlement, which in 1961 represented 9.46% of Slovakia's area, or 166 municipalities (Sitár 1967). According to the regionalisation of areas with the occurrence of dispersed settlements, the Bošácka dolina valley is located in the so-called Kopanice area of the Biele Karpaty mountains (White Carpathians) and the Myjava Uplands (Lauko et al. 2013). This specific form of settlement can also be found in other countries (Czechia, Japan, Spain, USA, etc.), and its value lies mainly in its limited occurrence (Petrovič and Petrikovičová 2021), social and historical value (Angelstam et al. 2021) and the connection of rare biotopes to this type of settlement (Moravčík and Benová 2021 and Špulerová et al. 2022). Furthermore, the value of locations with dispersed settlements has been enhanced by their gradual disappearance or transformation in recent decades (Rosner and Wesołowska 2020 and Najdený and Gurňák 2022). The transformation of dispersed or rural settle-

ments per se has several causes, beginning with political changes connected to historically changing land ownership conditions, social changes implied by time-changing priorities and preferences for housing, employment, etc., demographic changes (ageing and migration) and others. The consequence of these changes is the transformation of the traditional agricultural and residential function of such dispersed settlements (Rosner and Wesołowska 2020), which is also related to the change in the use of the land itself (Najdený and Gurňák 2022). Therefore, land use, which we perceive identically to Hasan et al. (2020) as a "mirror" of the current socioeconomic development, is directly related to settlement, and in our work we also start from the idea that the change in the way of life of the population, the development of society, etc., determines land use change. We can implicitly see an analogous approach in the works of Xia et al. (2021), Stevens et al. (2020) and others.

Several studies have stressed the transformation processes of settlements noticeable in rural regions in Slovakia (Jaszczak et al. 2018 and Maris 2021) or explicitly in those with dispersed settlements (Belčáková et al. 2021, Hanušin 2021, Petrovič and Petrikovičová 2021 and Murin 2022), however, none of the existing and recent studies have examined the issue at the level of residential units. Although the work of Trembošová et al. (2023) uses such data such as with the example of the Novobanská štálová area, it does so in the context of food availability. Data on the number of inhabitants of the Kopanice region represent a fundamental attribute in the very delimitation of territories with dispersed settlements. We emphasise this fact due to the necessity of updating the extent of existing areas with dispersed settlements. The aim of this paper is to analyse the quantitative development and spatial changes of the settlement in the Bošácka dolina valley, based on a database of buildings created from the digitalisation of long-term land cover, combined with data from municipal chronicles, interviews with mayors, historical population censuses, and field research. Land cover data are increasingly being used to estimate the number of inhabitants, which, depending on the land cover class, can with a certain probability predict and estimate the number of inhabitants of the territorial unit (Sládeková Madajová and Hurbánek 2016 and Stevens et al. 2020). Our aim in this context was to estimate the number of inhabitants living within the built up area (the so-called intra-village area) and outside the built-up area (the so-called extra-village area) of each of the five municipalities of the Bošácka dolina valley, based on our own detailed database of the landscape cover of the Bošácka dolina valley.

## THEORETICAL FRAMEWORK

Humans appeared in the studied area (the Trenčianske Bohuslavice locality) as early as in the later Palaeolithic (Vlačiky et al. 2013). Practically from the Neolithic period the settlement of the lower areas near the mouth and in the lower part of the Bošácka dolina valley is documented. Hillforts in the Bošácka dolina valley, located at elevations of up to 500 m above sea level, date from the Bronze Age. Historically, settlement of the territory is documented from the 13th and especially the 14th centuries (Trenčianske Bohuslavice – 1208, Haluzice – 1332, Bošáca – 1380 and Zemianske Podhradie – 1397) – Kravarčík et al. (2012). However, Wallachian and Kopanice colonisation (16th – 19th centuries), which determined the development of the dispersed settlements, became essential for the character of the settlement together with it the emergence of a cultural landscape with great biodi-

versity and historical landscape structures (Špulerová et al. 2017). The definition of a dispersed settlement, which is often determined by historical development and a specific region, can be found in a number of works (e. g. Hromádka 1943, Huba 1989, Omasta 2010, Van De Velde et al. 2010 and Amate et al. 2016). A dispersed settlement consists of one or more buildings (the specific number varies depending on the author) located outside the center of a settlement area. Even though this type of settlement can be found on every continent, with the exception of Antarctica, the historical circumstances of the establishment of dispersed settlements vary greatly (Connor 2018). In the case of Slovakia, this was an emergency solution for the past generations caused by the search for new, often less fertile land in more remote areas. Changes in the structure of dispersed settlements were historically implied by centralisation tendencies from the second half of the 20th century (Huba 1997), and the subsequent loss of the population's 'relationship' with the land was a result of collectivization, which compounded by changes in social values and lifestyles (Lieskovský et al. 2015 and Estoque et al. 2019). Recently, localities with dispersed settlements are characterised by a functional transformation, i.e., the transition into seasonal dwellings, second housing (cottages), or objects for individual recreation (Najdený and Gurňák 2022). The mentioned processes have also impacted the land cover of areas with scattered settlements, where the dominant processes include agricultural extensification and afforestation (Moravčík and Benová 2021 and Švoňavová et al. 2024). The housing fund is intrinsically related to dispersed settlements. Analysis of built-up areas at the level of individual buildings has not been conducted in Slovak literature, and it is minimally addressed internationally (e. g. Burnet et al. 2021 and Xia et al. 2021). This is likely due to the financial and time demands of such research. However, it should be noted that this type of research is directly related to the abandonment of agricultural land (historical landscape structures), where the factors determining the abandonment of cultural landscapes correlate with the factors influencing the abandonment or disappearance of settlements, as highlighted in the work of Xia et al. (2021).

In the context of settlement transformation, the dilapidation of buildings is a problematic fact, and not only from the point of view of remote sensing, but also in relation to the time interval between the abandonment of a building and its possible reclassification as defunct (Burnet et al. 2021). In this context, the process of settlement (building) extinction is unique. Unlike land cover changes, which are temporally dynamic, the extinction of buildings is usually gradual. This process – spanning from permanently inhabited buildings to recreational use, abandonment, and eventually extinction – can take decades, depending on the building materials. However, the perspective of future research on the functional transformation of buildings in relation to settlement, for example, is debatable due to the sensitivity of the data. Even though statistical data are collected point by point in Slovakia and in other countries, their publication for aggregated territorial units (municipalities, districts, ...) significantly limits the research possibilities of geographers. For this reason, even in the last century, efforts to harmonise inconsistent spatial entities began. This is referred to in professional geographic literature as the harmonisation of geographic data (Sládeková et al. 2016). In the domestic literature, Sládeková et al. (2016), for example, focused on this issue and possible methods of area transformation, while Wu and Murray (2007), Wardrop et al. (2018) and Stevens et al. (2020) did so abroad. The importance of aggregating and disaggregating statistical data for certain spatial units is important for municipalities, non-governmental or-

ganisations and commercial companies in relation to planning, electoral processes, the availability of services (e. g. the availability of public transport), risk analysis, disaster management and potentially many other uses (Wardrop et al. 2018). Among the wide scale of methods intended for the harmonisation of geographic data, we will mention above all the dasymetric method. With this method, a territory is disaggregated into relatively homogeneous areas in relation to the studied quantitative data (e. g. the number of inhabitants), or into auxiliary areas in relation to the studied variable, the overlapping of which creates dasymetric zones containning information about partial zones (Sládeková Madajová and Hurbánek 2016). It was this method that several authors applied (e. g. Wu and Murray 2007, Wardrop et al. 2018 and Stevens et al. 2020) to approximate the number of inhabitants, while data on land use/land cover turned out to be the most appropriate in this context. In the case of population estimation, the class "built-up area", or specific buildings, proved to be the best indicator, according to Stevens et al. (2020).

## DATA AND METHODS

The data utilized in this study originate from the digitization of the built-up areas of the subject territory in the years 1853, 1950, and 2020, which had distinct characteristics (see Najdený and Gurňák 2022). Initially, all roofed structures with an area of 25 square meters or more were mapped as individual polygons. Objects mapped in this way were not differentiated in terms of their function, with the exception of part of the municipality of Nová Bošáca (Fig. 2). Spatial characteristics of individual buildings were analysed using the nearest neighbor method and Kernel density estimation in GIS software. To estimate the population of selected territorial units in the Bošácka dolina valley, we calculated the average number of inhabitants per building. To ascertain the actual population in the Kopanice area, we selected a study territory representing typical dispersed settlement patterns. Such a territory within the Bošácka dolina valley is Nová Bošáca municipality, which was part of the Bošáca municipality until 1950 and was then called Bošácke kopanice. We studied an area covering 902 ha, which represents 12.61% of the area of Bošácka dolina valley and 26.97% of the area of Nová Bošáca (Fig. 2). Determining the period of a building's demise and its subsequent reclassification as a defunct building was also problematic in relation to remote sensing (Burnet et al. 2021). The number of buildings in a specific area (in the intra-village area and in the extra-village area) was determined using structured query language. The nearest available year was chosen for the number of inhabitants of a municipality. For the surveyed year 1853 this was data from 1869 (3 132 inhabitants of the Bošácka dolina valley), for the second mapped year 1950 it was data from the census of 1961 (6 032 inhabitants) and for the last year (2020) data from the 2021 census (4 194 inhabitants) were used. The 1961 census was selected over earlier censuses because it includes data on the newly independent Nová Bošáca (since 1950). Additionally, from 1961 onwards, the population censuses conducted in the territory of present-day Slovakia are considered modern, providing improved data quality and greater informational value. Despite the available statistical data, however, it is not possible to answer several fundamental questions about the spatial distribution of the population for the studied region. This primarily pertains to the population numbers in the intra-village area and extra-village area of the municipality, highlighting the contrast between the actual population in dispersed settlements and the

central area of the municipality. The mentioned missing data at the level of address points is a necessity for the relevant delimitation of municipalities with dispersed settlements. The qualified estimate of the proportion of uninhabited houses in the extra-village area was provided by the mayors of each municipality in the Bošácka dolina valley (Nová Bošáca, Zemianske Podhradie, Bošáca, Haluzice and Trenčianske Bohuslavice) and was determined based on interviews with the mayors. The obtained values were mostly adjusted to the mean value, as the responses were given as intervals. In the case of Nová Bošáca, based on our own research of the area with a dispersed settlement, we modified the value to the lower limit of the mayor's estimate (30% instead of the median value of 35%). The reason was, among other things, a comparison of the final estimate of the population of the extra-village area with reality, since in the case of a value of 35%, an estimated 316 inhabitants would thus have lived in the extra-village area in 2020, in contrast to 367 inhabitants at the value of 30%. The first of the listed values (316 inhabitants) would be correct if the character of the settlement of the extra-village area was relatively homogeneous (the same dispersed settlement with approximately the same proportion of uninhabited houses), which was also confirmed by the calculation: the number of buildings in the extra-village area of Nová Bošáca (1 183) * number of population per building in the case study of the region in the municipality (0.27) = 319. However, field research as well as the interview with the mayor indicated that the proportion of uninhabited houses around the Bošácka floodplain and the Predpolomský potok brook is significantly lower in the extra-village area than in the case of the surrounding dispersed areas. Based on these facts, we used a value of 30% for uninhabited houses in the extra-village area of Nová Bošáca.

Next, we mapped the structure of buildings by function and occupancy in a selected part of the Bošácka dolina valley known for its dispersed settlements. The aim was to demonstrate the present state of the population of the Kopanice area in relation to the functional transformation of these settlements (Huba 1997 and Lauko 1999). We chose the right-bank part of the Bošácka watercourse in the cadastral territory of Nová Bošáca (902 ha, 12.61% of the Bošácka dolina valley area) as our studied area, from which we extracted the territory immediately adjacent to the watercourse. The reason for excluding this part of the territory was the continuous nature of the settlement. The distance between individual clusters of buildings exceeded 200 meters in only two cases (244 meters and 230 meters), and the large number of buildings does not meet the attributes of a dispersed settlement, according to several authors (Verešík 1974a and Omasta 2010). This statement is also supported by the fact that the territorial plan of Nová Bošáca, which is being prepared, works with this territory as intra-village area, and in the future it is expected that this area will probably be incorporated into the current intra-village area of the municipality. Detailed field research of buildings was carried out in 2022 in this area (with an emphasis on the housing stock), the purpose of which was to determine the function, technical condition and occupancy of the buildings. What's more, residents were questioned in the form of interviews in order to find out the occupancy of buildings and the number of permanent residents living in objects identified as dwellings. Data on the residence of the owners of the land on which the houses were located were obtained from the database of the ÚGKK SR (2024). Based on the results of this case study in Nová Bošáca, we approximated the number of inhabitants according to the built-up area class. The approximation of the

number of inhabitants according to the number of buildings in the selected territories is based fundamentally on three variables: the number of buildings in the given territory, the number of inhabitants of the entire municipality and a qualified estimate of the share of unoccupied residential houses in the extra-village area. The qualified estimate of the mayors is corroborated by our case study in a sparsely populated area. The population estimate itself was calculated based on the following formula for each municipality of the Bošácka dolina valley and its intra-village area/extra-village area in 2020:

$$\textit{extravilan population of municipality } x_{year} = \left(\frac{\sum of\ buildings\ in\ municipality\ x_{year}}{\sum of\ population\ in\ municipality\ x_{year}}\right) * \left(\sum of\ extravilan\ buildings\ in\ municipality\ x_{year} - \frac{\%\ estimate\ of\ mayor}{100} * \sum of\ extravilan\ buildings\ in\ municipality\ x_{year}\right)$$

$$\textit{intravilan population of municipality } x_{year} = \left(\frac{\sum of\ buildings\ in\ municipality\ x_{year}}{\sum of\ population\ in\ municipality\ x_{year}}\right) * \left(\sum of\ intravilan\ buildings\ in\ municipality\ x_{year} - \frac{\%\ estimate\ of\ mayor}{100} * \sum of\ intravilan\ buildings\ in\ municipality\ x_{year}\right)$$

For the calculation of the estimated number of inhabitants based on the number of buildings in the years 1853 and 1950, we did not apply the mayors' estimates reflecting the share of uninhabited houses, since in both years this phenomenon (recreational/weekend and uninhabited houses) did not exist or was of marginal importance. As a result, the formula looked as follows:

$$\textit{extravilan population of municipality } x_{year} = \left(\frac{\sum of\ buildings\ in\ municipality\ x_{year}}{\sum of\ population\ in\ municipality\ x_{year}}\right) * \left(\sum of\ extravilan\ buildings\ in\ municipality\ x_{year}\right.$$

$$\textit{intravilan population of municipality } x_{year} = \left(\frac{\sum of\ buildings\ in\ municipality\ x_{year}}{\sum of\ population\ in\ municipality\ x_{year}}\right) * \left(\sum of\ intravilan\ buildings\ in\ municipality\ x_{year}\right)$$

The realised estimates of the number of inhabitants in the intra-village area and extra-village area should be taken as a rough estimate. The purpose was mainly to demonstrate the changing ratio of the number of inhabitants between the current intra-village area and extra-village area in the analysed cross-sectional years.

## RESULTS

The change in the spatial character of the settlement is evident when examining detailed land cover maps from different years. However, by representing the nuclear density of buildings, we could better illustrate their spatial distribution cartographically (Fig. 1), particularly in areas with dispersed settlements in the northern part. Several processes and trends can be observed in the spatial structure of buildings in space and time (Fig. 1). The first is the significant increase in the built-up area, which is, with the exception of agro-industrial area, characterised especially by new non-residential and residential construction. The second is a significant increase in the concentration (clustering) of buildings in the municipalities, or in their current intra-village area and along the main traffic arteries of the region, which is directly associated with the increase in compactness, or the decrease in the dispersion of the settlement. This process aligns with what Song and Li (2020) refer to as the diffusion mode, an evolutionary phase in the development of rural settlements. A third process is also connected with this, mainly in the cadastral area of Nová Bošáca, where the share of dispersed settlements is the largest, and thus the disappearance of several lone buildings, or hamlets with a smaller number of houses. In tab. 1 we can see that the number of buildings in the Bošácka dolina valley increased by 878 (116.76% increase) between the years 1853 – 1950, and in the years 1950 – 2020 it was 3 810 buildings (a 233.74% increase). This supports the above-mentioned claims about the increase in the number of buildings, their growing compactness, or the loss of the scattered character of the population of the subject area. Analogously, the size of the built-up area also grew, which in 1853, 1950 and 2020 had an area (share of the area of the Bošácka dolina valley) of 13.54 ha (0.20%), 27.50 ha (0.38%) and 60.86 ha (0.85%) respectively. The percentage increase in the number of buildings was different in individual municipalities, namely from 70.01% in Bošáca to 146.39% in Zemianske Podhradie in the years 1853 – 1950. Between 1950 – 2020, the increase was from 117.00% in Haluzice to 565.12% in Trenčianske Bohuslavice.

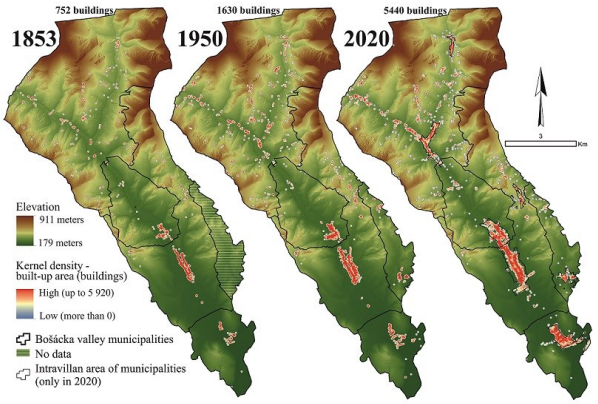


Fig. 1. Density of built-up area (buildings) in the Bošácka dolina valley in years 1853, 1950 and 2020

Sources: own research, LLS: ÚGKK SR (2024).

We present the increasing compactness of the settlement through the decreasing average distance between the nearest two buildings (tab. 1), which gradually fell in the subject area from 38 m in 1853, to 31 m in 1950 and to 17 m in 2020. At the level of municipalities, this value in 1853 and 1950 was the highest (settlements were scattered) in Nová Bošáca (65 m and 40 m respectively) and in the year 2020 in Haluzice (27.54 m). In contrast, the lowest distance (the most compact settlement) in all three years (1853, 1950 and 2020) occurred in today's municipality of Bošáca (23 m, 26 m and 15 m). The clustering of buildings per se is presented by the nearest neighbour index, which reaches a value less than 1, meaning the clustering is statistically significant (z-score < -1.96) for $p < 0.001$. The paradoxical results, in which Bošáca with its dispersed settlements (Rolincová and Zabudišová) statistically the most compact settlement, are caused by the "average" value, since most of the buildings (a large absolute number) are located in the intra-village area and, on the other hand, by the fact that the applied GIS tool works with air and not road distances. Finally, this value is distorted by the above-mentioned pecularity of the mapping, which does not distinguish between commercial and residential buildings. In this we can see a certain disadvantage of the applied GIS method. Nevertheless, at least in the last two mapped periods, Trenčianske Bohuslavice can be described as a municipality with the most compact settlement of the Bošácka dolina valley regarding the spatial character of the buildings.

**Tab. 1. Average nearest neighbour analysis of buildings in the Bošácka dolina valley in years 1853, 1950 and 2020**

| | 1853 | 1950 | 2020 |
|---|---|---|---|
| Sum of buildings | 752 | 1,630 | 5,440 |
| Observed mean distance (m) | 38.0384 | 31.9174 | 17.0743 |
| Expected mean distance (m) | 134.8848 | 104.7344 | 57.3302 |
| Nearest neighbour index* | 0.2820 | 0.3047 | 0.2978 |
| z-score** | -41.8883 | -53.6992 | -99.0777 |
| p-value | < 0.001 | < 0.001 | < 0.001 |
| Area (ha) | 6 768.13 | 7 151.98 | 7 151.98 |

Source: own research.

Explanations: * NN index < 1 means clustering and NN index > 1 means random distribution; ** Quantifies the degree of difference between the pattern of measured and expected values in the context of clustering (z < - 1.96 indicates clustering) for $p < 0.001$.

## Case study of the functional use of buildings in a part of the Bošácka dolina valley

Using results of remote sensing, field research and interviews, we identified 179 buildings (9.95% of buildings in Nová Bošáca) in the defined area, of which we identified 82 (45.81%) as residential buildings, 86 (48.04%) as commercial and other buildings and 9 (5.03%) as dilapidated residential buildings. Of the 82 residential dwellings, we identified a permanent population in 22 (26.83%) houses, while 60 (73.17%) houses were used for recreational purposes, or as seasonal dwellings (cottages). At the same time, 49 people live in the 22 permanently inhabited houses (average = 2.29; median = 2), which represents an average of 2.29 inhabitants per permanently inhabited house, 0.59 inhabitants per residential house and 0.27 inhabitants per building in the defined territory. Based on our findings, the population density (number of inhabitants per $km^2$) in the analysed area is thus

only 5.43, while in the whole of Nová Bošáca it is 30.71 and in the Bošácka dolina valley 58.64 for year 2021, according to the data of the Statistical Office of the Slovak Republic (ŠÚ SR 2021). The spatial distribution of inhabited and uninhabited houses is shown in Fig. 2, from which it can be inferred that one of the many factors determining the occupancy of houses is transport accessibility, since most of the permanently inhabited houses are located in lower positions near the main road infrastructure.

In addition to information on the function, occupancy and number of inhabitants, we also investigated the permanent residence of the owners of the buildings in the selected area from the database of the Slovak registry (ÚGKK 2024). The results show a strong relationship between the permanent residence of the owner and the occupancy of the house (Fig. 3), with the Slovak district in which the monitored territory is located (Nové Mesto nad Váhom) dominating in the context.


Fig. 2. Occupied and unoccupied houses in an area of dispersed settlements, using the example of a selected area of Nová Bošáca

Sources: own research, GKÚ Bratislava, NLC (2022).

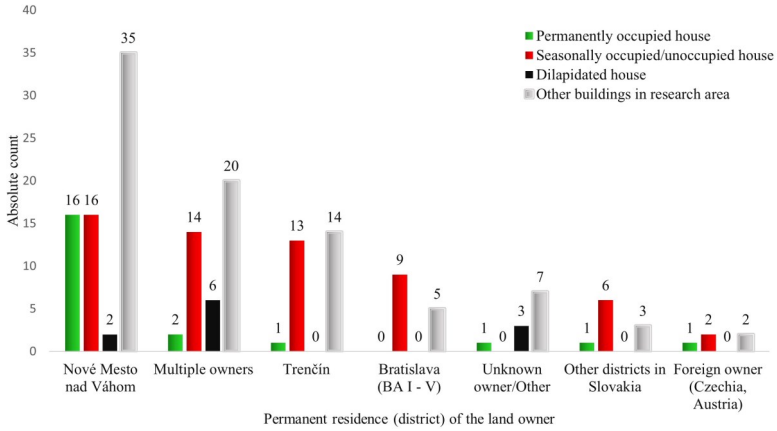


Fig. 3. Structure of buildings according to "occupancy" and residence of its owner (selected area of Nová Bošáca)

Sources: own research, ÚGKK (2024).

Among the districts of the Slovak Republic in which the owner of an uninhabited house also has permanent residence were in Nové Mesto nad Váhom, Trenčín, the districts of Bratislava, Dunajská Streda, Piešťany, Liptovský Mikuláš and Senec. The ownership structure of dilapidated residential buildings is noteworthy in this context, as it confirms the hypothesis of the municipality mayor that the unsettled ownership structure is one of the barriers to development of the municipality (9 out of 11 dilapidated buildings had multiple owners, or the owners were not known).

Approximation of the population in the municipalities of the Bošácka dolina valley

The results show that although the area of buildings (built-up area) increased from 13.54 ha to 60.86 ha between 1853 and 2020, its share in the intra-village area of the municipality grew faster than in the extra-village area. The largest increase occurred during the period of centralisation (1950s). The current trend is identical, caused mainly by the spatial planning documentation (the Territorial Plan of the Municipality), reinforced by large protected areas covering 67.24% of the area of the Bošácka dolina valley. In the next few years, the absolute area or number of buildings in the extra-village area is expected to remain stable or increase slightly. However, due to the significant development and probable expansion of the intra-village area, the relative share of built-up area in the extra-village area will decrease. A problematic factor in estimating the number of inhabitants in the study area is the proportion of unoccupied houses that serve as holiday homes or are in a state of disrepair. The share of such houses in the part of Nová Bošáca analysed above is 73.17%. The extreme case is Haluzické kopanice, where only 1 out of 52 buildings is inhabited, which represents more than 98% of uninhabited houses. These areas contrast with the compact character of Trenčianske Bohuslavice, where there are currently no scattered settlements. It is necessary to mention the areas of the former Nová Bošáca village, located on the floodplain of the Bošáčka and Predpolomský brooks, where the proportion of uninhabited houses is very low, which is also one of the reasons for the plans to incorporate these areas into the intra-village area in the future. In view of the above-mentioned and spatially highly variable values of the share of uninhabited houses, we used the estimate of the mayors of the municipalities in the Bošácka dolina valley for the calculation of the number of inhabitants based on the number of buildings, according to which 17.82% of the houses in the extra-village are uninhabited (from 30% in Nová Bošáca to 1.3% in Trenčianske Bohuslavice).

At the level of the municipalities, in 2020 the largest percentage of inhabitantd in the absolute number (relative value), the largest percentage of inhabitants lived in the extra-village area of Nová Bošáca (35.76%), Bošáca (13.37%), Zemianske Podhradie (13.61%), Trenčianske Bohuslavice (11.39 %) and the smallest in Haluzice (19.87%). The figure for the whole Bošácka dolina valley this was 18.25% (tab. 2). In 1950, based on the absolute number of inhabitants (relative value), the most populated of today's extra-village area were in the municipalities of Nová Bošáca (81.34%), Bošáca (14.19%), Zemianske Podhradie (11.72%), Haluzice (30.00%) and the least in Trenčianske Bohuslavice (8.53%). In the Bošácka dolina valley as a whole, a total of 38.13% of the population lived in the extra-village area, of which 77.03% were in Bošácke Kopanice (today's Nová Bošáca). In 1853, among the most populated extra-village area were Nová Bošáca (89.11%), Bošáca (13.61%), Zemianske Podhradie (19.59%), while the least populated was the extra-

village area of Trenčianske Bohuslavice (11.11%). During this period, 38.79% of the population lived in the extra-village area, of which 73.98% lived in Bošácke Kopanice (Nová Bošáca). For comparison, we also present the number of inhabitants per residential house/apartment in 2020 according to the ŠÚ SR 2021 (our value according to the calculation): Trenčianske Bohuslavice – 2.62 (1.13), Zemianske Podhradie – 2.55 (0.90), Bošáca – 2.42 (0.79), Nová Bošáca – 1.65 (0.57), Haluzice – 1.10 (0.35). Although the individual values are different for one municipality, the mutual ratio is relatively fixed, which was also confirmed by the mutual correlation, where the correlation coefficient *r* reached the value of 0.94.

**Tab. 2. Estimate of the number of inhabitants living in the current intra-village area and extra-village area of the Bošácka dolina valley in 1853, 1950 and 2020**

| | Bošácka dolina valley 1853 | | | Bošácka dolina valley 1950 | | | Bošácka dolina valley 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intrav. | Extrav. | Total | Intrav. | Extrav. | Total | Intrav. | Extrav. | Total |
| Population* | - | - | 4,183 | - | - | 6,032 | - | - | 4,194 |
| Number of buildings | 454 | 301 | 755 | 1,004 | 626 | 1,630 | 3,705 | 1,735 | 5,440 |
| Share of buildings | 60.13% | 39.87% | 100.00% | 61.60% | 38.40% | 100.00% | 68.11% | 31.89% | 100.00% |
| Number of inhabitants on the building | - | - | 5.54 | - | - | 3.70 | - | - | 0.77 |
| Share of uninhabited residential houses in the extra-village area** | - | ≈ 0% | - | - | ≈ 0% | - | - | ≈17.82% | - |
| Number of inhabitants according to the number of buildings *** | 2,561 | 1,622 | 4,183 | 3,732 | 2,300 | 6,032 | 3,429 | 765 | 4,194 |

Source: own research.

Explanations: * year 2020 – 2021 Census, year 1950 – 1961 Census, year 1853 – data from 1869 from Ochodnický and Dzurák (1994); ** qualified estimate of the mayors of individual municipalities – applied only for the year 2020; *** approximation of the number of inhabitants considering the share of uninhabited houses in the extra-village area of the municipality.

For mutual comparison, we present the population density (number of inhabitants per km$^2$) of the built-up area, unbuilt-up area and the whole territorial unit in 1853, 1950 and 2020 (Fig. 4). Given the size of today's built-up areas (their share in the area of the municipality), which range from 0.25 km$^2$ (6.48%) in Haluzice to 1.31 km$^2$ (6.71%) in Bošáca, it is understandable that the population density in the built-up areas exceeds the density in the unbuilt-up areas by several times. In this context, the development of individual municipalities is quite remarkable and can be divided into two groups. The first group (the municipalities of Nová Bošáca and Trenčianske Bohuslavice) recorded a continuous and relatively dynamic increase in the built-up area population density in all three years examined. It is necessary to distinguish between two diametrically different development trajectories of these municipalities. In the case of Nová Bošáca, in addition to the concentration tendencies[1], this included the abandonment of Kopanice or its functional transformation. In the case of Trenčianske Bohuslavice, in addition to the concentration of new housing construction (before 1989) as a result of the nearby Hydrostav site, the factor of good transport accessibility and the peripheral suburbanisation of

[1] In the years 1853 (*de jure*) and 1950 *de facto*, there was no centre in Nová Bošáca.

Trenčín and Nové Mesto nad Váhom were observed, especially in the last two decades. At the same time, Trenčianske Bohuslavice is the only municipality in the Bošácka dolina Valley that has not experienced a decline, but rather an increase in the number of inhabitants and population density in the outlying areas of the municipality. This is mainly due to the lack of land for new construction in the municipality's built-up area (intra-village).

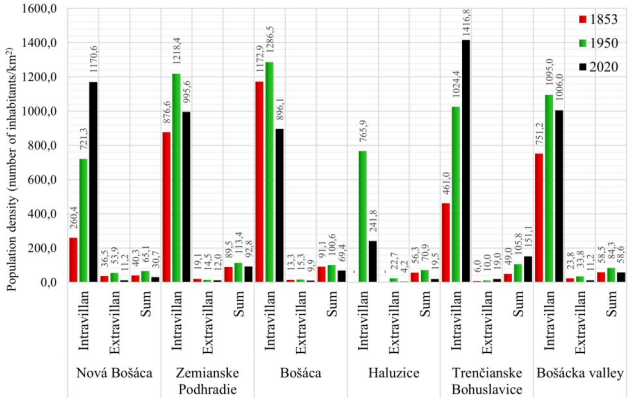


Fig. 4. Development of population density in the intra-village area/extra-village area of municipalities of the Bošácka dolina valley

Source: own research.

The second group consists of the municipalities of Haluzice, Bošáca, and Zemianske Podhradie (Fig. 4), in which an increase in population density to its maximum value in 1950, compared to 1853, and a subsequent decrease in 2020 can be observed. Together with the decline in population density, there was also a decrease in population density per unit of built-up area, which is implied by the construction of service infrastructure and commercial buildings, while the number of inhabitants is decreasing or stagnating. This trend is visible from the value of the number of inhabitants per building, which fell in the Bošácka dolina valley from 5.54 in 1853 to 3.70 in 1950 to the current 0.77 inhabitants per building. This value in 2020 was the lowest in those municipalities with a high proportion of dispersed settlements or uninhabited houses (Haluzice – 0.35 and Nová Bošáca – 0.57).

## DISCUSSION

Numerous studies have focused on the transformation processes of rural landscapes and their settlements (Agnoletti et al. 2019, Belčáková et al. 2021, Burnet et al. 2021 and Švoňavová et al. 2024), mainly focusing on the 20th and 21st centuries (Hanušin 2021 and Švoňavová et al. 2024). Our research, however, covers a longer time horizon (from the mid-19th century to the present), insights into long-term spatiotemporal transformations. The contribution of the study also investigates spatiotemporal changes in rural settlements using detailed data from land cover mapping (individual buildings). This methodological approach represents an innovative perspective, although the collection of historical data remains costly and time-consuming. Such detailed data on built-up areas can be utilized for various analyses. One potential application demonstrated in this study is population ap-

proximation based on individual buildings. Although population estimates based on land cover have been explored in previous works (Alahmadi et al. 2014, Sládeková Madajová and Hurbánek 2016 and Stevens et al. 2020), our application to a rural landscape is relatively novel. We believe that this approach has provided relatively accurate population estimates, even though we had to account for the unique dispersed settlement pattern in the Bošácka dolina valley. Prospectively, a similar approach could be applied across Slovakia to reassess the extent of dispersed settlements, as the current delineation of these areas is approximately 60 years old (Verešík 1974b). Our study, along with others (e.g., Jaszczak et al. 2018 and Maris 2021), highlights the changing nature of dispersed settlements.

In line with several studies (Belčáková et al. 2021 and Petrovič and Petrikovičová 2021), the functional transformation of areas with dispersed settlements into (seasonal) recreational zones or seasonal residences, or their eventual abandonment, has been observed. This transformation is associated with population decline in these areas, as confirmed in our study of the Bošácka dolina valley.

Considering the study's results, it is necessary to draw attention to some limitations of the explained approach. The first limitation is that our analysis encompasses built-up areas, including not only residential buildings but also various associated structures, such as commercial and other buildings. We believe that this factor did not significantly affect the quality of our results, but it must be considered when interpreting the outputs. Additionally, it is important to emphasize that most works (e. g., Wu and Murray 2007) estimating the population of a disaggregated territorial unit focus on urban populations/regions. Our study is focused on rural areas. Furthermore, compared to our work, most studies use small-scale land use maps (e. g., Stevens et al. 2020).

The second limitation of the research pertains to the specificity of the studied area, which is characterized mainly by dispersed settlement, thus focusing primarily on a particular type of (rural) settlement in Slovakia. Last but not least, it is necessary to take into consideration the spatially heterogeneous proportions of seasonally occupied dwellings, which directly relate to the occurrence of dispersed settlements.

Regarding specific findings, our analysis of the Bošácka dolina valley, while considering the outlined limitations, can be extended to rural regions both within Slovakia and internationally. In this context, it is important to note that although the transformation of rural regions is relatively well-analysed in the literature, the emphasis on the transformation of settlements at the local level is minimal, even though several authors highlight its significance (e. g., Sikorski et al. 2020).

## CONCLUSION

In our study, we focused on analysing changes in the spatial characteristics of rural settlements over a period of approximately 170 years. The results indicate a gradual concentration of settlements, driven by new residential construction in the intra-village areas of the municipalities and the nearby hinterland. In parallel, the original dispersed settlements in the extra-village area are disappearing or undergoing functional transformation into recreational facilities, such as cottages. Our case study found that in some territories, the share of unoccupied residential houses can be as high as 73.17%. Throughout the analysed period (1853 – 2020), we recorded a gradual increase in the concentration of settlements (buildings), peaking in the

present day. Interestingly, while the number of buildings increased from 755 (13.54 ha) in 1853 to 5,440 (60.86 ha) in 2020, the population remained almost identical in these years. The results, which approximate the population based on the number of buildings, support the above statements about the functional transformation and gradual disappearance of dispersed settlements. The share of residents in extra-village areas of the Bošácka dolina valley municipalities fell from 38.78% in 1853 to 38.13% in 1950, and further down to 18.24% in 2020. This population decline has naturally affected the region's infrastructure and character of landscape. Our findings confirm the pan-European trend of rural depopulation, showing significant spatial differentiation even within relatively small areas. Municipalities with dispersed settlements have generally experienced significant population declines, while those with compact settlements have been growing or remaining stable.

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**GEOGRAFICKÝ ČASOPIS / GEOGRAPHICAL JOURNAL** 76 (2024) 3, 279-295

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# ČASO-PRIESTOROVÉ ZMENY RURÁLNEHO OSÍDLENIA: PRÍPADOVÁ ŠTÚDIA BOŠÁCKEJ DOLINY

Rozptýlené osídlenie predstavuje špecifickú formu, ktorej hodnota spočíva v obmedzenom výskyte, kultúrno-historickej hodnote a pozostatkoch chránených krajinných štruktúr v týchto lokalitách. Regiónom s rozptýleným osídlením je aj Bošácka dolina (Biele Karpaty, Západné Slovensko). Naším cieľom bolo analyzovať transformačné procesy rurálneho osídlenia v priestorovom kontexte, vrátane aproximácie počtu obyvateľov, prostredníctvom detailnej analýzy zastavanej plochy – budov v časovom horizonte približne 170 rokov. Súčasťou analýzy je aj podrobný prieskum funkčného využitia domového fondu vo vybranej časti skúmaného regiónu. Naše výsledky potvrdili celoeurópsky trend depopulácie rurálnych oblastí, pričom tieto tendencie sa ukázali byť priestorovo diferencované aj v rámci Bošáckej doliny. Najväčší pokles počtu obyvateľov zaznamenáva práve rozptýleným osídlením typická obec Nová Bošáca, zatiaľ čo obec Trenčianske Bohuslavice s kompaktným osídlením populačne narastá. Paralelne s týmto môžeme sledovať, že pôvodné samoty, viesky či samostatne stojace budovy v extraviláne zanikajú alebo podliehajú funkčnej transformácii na rekreačné objekty – chalupy a chaty. S počtom budov je úzko prepojený aj počet obyvateľov. V tomto kontexte je pozoruhodné, že kým v roku 1853 bolo v Bošáckej doline 755 budov, tak v roku 2020 to bolo až 5 440, pričom počet obyvateľov bol v týchto rokoch takmer identický. Rozloha budov sa v období rokov 1853 – 2020 zväčšila o 349,48 % (z 13,54 na 60,86 ha). Vzhľadom na potrebu analýzy počtu obyvateľov v extraviláne a intraviláne obcí skúmaného územia a absenciu takýchto dát boli tieto hodnoty aproximované podľa počtu budov. Výsledky podporili uvedené tvrdenia o funkčnej transformácii a postupnom zániku (transformácii) rozptýleného osídlenia, keďže práve podiel obyvateľov extravilánu obcí Bošáckej doliny klesol z 38,78 % v roku 1853 na 38,13 % v roku 1950 a v roku 2020 až na 18,24 %. Tento úbytok populácie nielen na kopaniciach sa zákonite odrazil aj na infraštruktúrnej vybavenosti regiónu a podobe krajinnej pokrývky.

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