ISSN 0354-8724 (hard copy) | ISSN 1820-7138 (online)

Geospatial Analysis of Population Ageing in Bosnia and Herzegovina

Alma Kadušić[A*], Sabahudin Smajić[A], Suad Kunosić[B], Nedima Smajić[A]

Received: December 28, 2022 | Revised: March 09, 2023 | Accepted: March 10, 2023
doi: 10.5937/gp27-41960

Abstract

The aim of this research is to analyze the spatial distribution of the population ageing in Bosnia and Herzegovina and identify areas of the country that are particularly vulnerable to negative demographic trends. To achieve the goal of the study, data on the ageing coefficient and ageing index for the period 2013-2020 were used. The geospatial analysis of these indicators was performed using global (Global Moran's I and Getis-Ord General G) and local (Anselin Local Moran's I and Getis-Ord G*) indexes of spatial autocorrelation. The research results confirmed the clustering of both indicators. Ageing coefficient values are clustered in municipalities in western, northwestern, eastern, and central Bosnia and Herzegovina. Ageing index values are clustered in municipalities in central, western, northwestern, and northeastern Bosnia and Herzegovina. This study provides insight into the research methods of spatial demographic trends and phenomena, and its findings can serve as a basis for future demographic research and development in Bosnia and Herzegovina.

Keywords: spatial analysis; spatial autocorrelation; spatial patterns; population ageing; Bosnia and Herzegovina

Introduction

The age distribution of a population is a vital indicator of its composition, which when analysed, can reveal the demographic development of a particular population. Analysis of age population composition, when applied to five-year age groups, can reveal the population's potential vitality and biodynamics. Demographic process of population ageing is a widespread phenomenon. The increase in the share of people who are 65 or older and the increase in the mean age of the population characterize this adverse demographic process in contemporary society (Wu et al., 2021; Li et al., 2019; d'Albris & Collard, 2013; Kerbler, 2015; Bucher, 2014).

Socio-economic, political, social, biological, and other factors at the beginning of the 21st century influenced Bosnia and Herzegovina's demographic trends, including the population's age structure. The total population of Bosnia and Herzegovina declined because of a considerable decrease in birth rates, a slight increase in mortality rates, and, consequently, low natural population change rates along with a negative migration balance. Bosnia and Herzegovina has recorded negative population change rates since 2007, and the country is still losing its youthful and productive population due to economic emigrations. All of the processes mentioned above have an effect on the population's ageing process, potential bio-dynamics, and population vitality or health (Kadusic & Suljic, 2018; Kadusic et al., 2016).

Spatial analysis is especially important in demographic analysis, and thus in the analysis of popu-

[A] Department of geography, Faculty of Natural Sciences and Mathematics, University of Tuzla, Univerzitetska 4, Tuzla 75000, Bosnia and Herzegovina
[B] Department of physics, Faculty of Natural Sciences and Mathematics, University of Tuzla, Univerzitetska 4, Tuzla 75000, Bosnia and Herzegovina
[*] Corresponding author: Alma Kadušić, e-mail: alma.kadusic@untz.ba

lation ageing and spatial differences in the level and causes of population ageing in different areas. The spatial autocorrelation method can be used to analyze the spatial distribution of different demographic processes, including population ageing. As a result, numerous studies in the field of spatial analysis of population ageing using spatial autocorrelation methods have been conducted. Wang (2020), for example, examined the spatial patterns and socioeconomic factors of population ageing on a global scale from 1990 to 2010. Káčerová et al. (2022) examined population ageing in Slovakia from 1950 to 2021, with a particular emphasis on spatiotemporal analysis. Guan et al. (2020) investigated the spatial and temporal variations of population ageing in China's Liaoning Province, whereas Chen et al. (2019) used spatial autocorrelation methods to investigate the spatial patterns of population ageing in China from 1998 to 2014. Reynaud et al. (2018) studied spatial distribution and patterns of population ageing in Italy from 2002 to 2014. Nikitović et al. (2016) used spatial autocorrelation indices to determine spatial patterns of demographic trends in Serbia from 1961 to 2010, and Kurek (2003) analyzed the spatial distribution of the ageing process in Poland from 1988 to 2001.

There have not been many studies on the spatial distribution and disparities of the population ageing process in Bosnia and Herzegovina. However, several studies on Bosnia and Herzegovina's demographic trends have been conducted. For example, Gekic et al. (2020) studied depopulation trends in Bosnia and Herzegovina at the end of the 20th and beginning of the 21st centuries, whereas Gekic et al. (2019) researched spatial differentiation of the age structure of the population in Bosnia and Herzegovina. Mijic & Ateljevic (2018) studied the use of contemporary GIS software in demographic research of the Bosnian entity of the Republic of Srpska. Kadusic et al. (2016) researched the causes and consequences of population ageing in Bosnia and Herzegovina. It should be noted that prior studies on population ageing and other demographic variables in Bosnia and Herzegovina did not make extensive use of spatial analysis and spatial autocorrelation methods.

The primary assumption of this research is that certain areas of Bosnia and Herzegovina are particularly at risk due to population ageing. As a result, the primary goals of this study are to investigate trends in population ageing and population change in municipalities of Bosnia and Herzegovina from 2013 to 2020, to analyze the spatial pattern of population ageing in Bosnia and Herzegovina using global and local autocorrelation statistics parameters, and to provide a geovisualization of population ageing spatial distribution.

Methods and data

Spatial analysis of demographic phenomena provides a comprehensive understanding of demographic processes and demonstrates the significance of spatial statistical techniques in the spatial analysis of demographic occurrences (Kurek et al., 2021, Nikitović et al., 2016). In this study, a spatial analysis of population ageing in Bosnia and Herzegovina was conducted using spatial autocorrelation methods in order to identify spatial clusters with high or low population ageing values. Spatial autocorrelation methods enable the analysis of the various variables and demonstrate how similar or different variables are in adjacent locations. Global statistical indices of spatial autocorrelation and local statistical indices can be distinguished. Global statistical indices can be used to analyze spatial autocorrelation through an entire dataset or statistical sequence. Local statistical indices of spatial autocorrelation can be used to identify hot and cold spot areas (Guan et al., 2020; Chen et al., 2019; Anselin, 1995; Ord & Getis 1995; Anselin & Getis, 1992).

Global statistical indices (Global Moran's I and Getis-Ord General G) and local statistical indices (Anselin Local Moran's I and Local Getis-Ord Gi*) were used to determine the spatial distribution of population ageing, that is, whether population ageing is clustered or dispersed in Bosnia and Herzegovina.

The value of the global Moran's I index ranges between -1 and +1. The research begins with the null hypothesis, which states that there is no spatial autocorrelation between variables. The statistical significance of global Moran's I is determined using the p-value and z-score. If the index value is significant and positive, the index value will vary between 0 and +1, indicating positive spatial autocorrelation and spatial clustering of values. If the global Moran's I is statistically significant and negative, its value will be in the range of 0 to -1, indicating a negative spatial correlation between the values and the data dispersion. Therefore, using this index, it can be determined whether the ageing is clustered, dispersed, or random.

The Global Getis-Ord General G Index indicates the clustering of low or high values. The index's results must always be interpreted in the context of the null hypothesis. If the null hypothesis is rejected (statistically significant p-value), a positive z-score value indicates the clustering of high values in the researched area. If the z-score value is negative, the low values are clustered in the study area.

The clustering of low and/or high values can also be determined using the Anselin Local Moran's I index. Positive and statistically significant z-score values reveal where high and low values are concentrated in the research area. Negative and statistically significant z-score values indicate spatial data outliers (low-high, high-low values).

In this study, the Local Getis-Ord Gi* Index of spatial autocorrelation was also utilized. This index identifies spatial clusters of statistically significant high and low values. For each feature in the Input Feature Class, a new Output Feature Class with a *z*-score, *p*-value, and confidence level bin is generated (Gi Bin). This index's high *z*-score and low *p*-value indicate hot spots, while its low negative *z*-score and low *p*-value indicate cold spots. The Gi Bin field reveals statistically significant hot and cold spots with a 99%, 95%, and 90% degree of confidence. Clustering for features in bin 0 is not statistically significant, whereas features in bins +/-3 show statistical significance with a 99% confidence level, features in +/-2 show statistical significance with a 95% confidence level, and features in +/-1 show statistical significance with a 90% confidence level.

As an indicator of population ageing in Bosnia and Herzegovina, the ageing coefficient, or the share of the population aged 65 and over in the overall population, and the ageing index, which compares the population older than 65 and the population 0 to 14 years old, for 142 municipalities, were calculated over the period from 2013 to 2020. The ageing coefficient and ageing index are often used indicators because they provide more detailed information on a population's ageing. These indicators are important for identifying areas where the population is ageing faster, comparing the ageing of populations of various sizes, and determining the degree of population ageing. Since the last population census in Bosnia and Herzegovina was conducted in 2013, age distribution estimates by municipalities in Bosnia and Herzegovina were acquired from the Agency for Statistics of Bosnia and Herzegovina (BHAS), Institute for Statistics of Federation of Bosnia and Herzegovina (FZS), and the Republic of Srpska Institute of Statistics (RZSRS).

In order to determine the main factors in the spatial distribution of the ageing process in Bosnia and Herzegovina, average death rates and other demographic indicators, like average birth rates, natural population change rates, vital indexes, and ageing coefficients, were calculated for 142 municipalities in Bosnia and Herzegovina over the course of eight years (2013–2020). Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to determine the distribution of the abovementioned datasets (Pallant, 2011). In order to determine the correlation between demographic parameters and indicators of population ageing in Bosnia and Herzegovina, the nonparametric method Spearman's Rank-Order Correlation was used.

Results

A variety of factors can influence population ageing, including demographic, economic, social, health and healthcare, and environmental factors (Wan et al., 2022; Beard & Bloom, 2015; Almedia de Melo et al., 2010). Many different factors influenced the ageing process of Bosnia and Herzegovina's population, but demographic factors and changes were the largest ones. According to Gekic et al. (2019), the demographic development of Bosnia and Herzegovina in the 20th century was significantly influenced by a number of complex social, political, and economic issues. This was most visible at the end of the twentieth century, during the war in 1992-1995, which resulted in significant negative demographic consequences. Bosnia and Herzegovina entered the twenty-first century with two distinct demographic depopulation processes: total depopulation and demographic ageing, both with distinct spatial-regional and with urban-rural population polarization (Gekic et al., 2019).

There is a significant correlation between the natural population rates of Bosnia and Herzegovina and its age structure. The war in Bosnia and Herzegovina from 1992 to 1995 resulted in major population shifts. The total population of Bosnia and Herzegovina has decreased due to war fatalities and forced migration. In addition to the adverse economic, social, political, and other situations, it resulted in a decrease in post-war population growth rates caused by negative population change rates and emigration of the young population (Table 1).

Table 1. Natural population change rates in B&H, 2013-2020

Year	Birth rates in ‰	Death rates in ‰	NPG* rate in ‰
2013	8.7	10.1	-1.4
2014	8.6	10.2	-1.6
2015	8.5	10.8	-2.3
2016	8.6	10.4	-1.8
2017	8.6	10.8	-2.2
2018	8.4	10.8	-2.4
2019	8.1	11.1	-3.0
2020	7.8	12.8	-5.0

** NPG - Natural Population Change*
Source: BHAS, 2022

Bosnia and Herzegovina's birth rates have a decreasing trend, whereas mortality rates have an increasing trend, which indicates that Bosnia and Herzegovina has entered a post-transition stage of demographic development. Negative natural population change rates have been recorded in this country since 2007. In 2013, the natural population change rate was -1.4, and in 2020 reached a value of -5.0‰. The result of a decrease in birth rates and natural population change rates was a decrease in the proportion of young people and an increase in the proportion of older people

Table 2. Spearman's Rank Order Correlation between ageing indicators and demographic variables in B&H, 2013-2020

Variable	Correlation	Age Coefficient	Ageing Index
Birth rates	Corr. Coefficient	-.467**	-.627**
	Sig. (2-tailed)	.000	.000
Death rates	Corr. Coefficient	.701**	.596**
	Sig. (2-tailed)	.000	.000
NPG*	Corr. Coefficient	-.852**	-.883**
	Sig. (2-tailed)	.000	.000
Vital index	Corr. Coefficient	-.830**	-.912**
	Sig. (2-tailed)	.000	.000

** Natural Population Change*

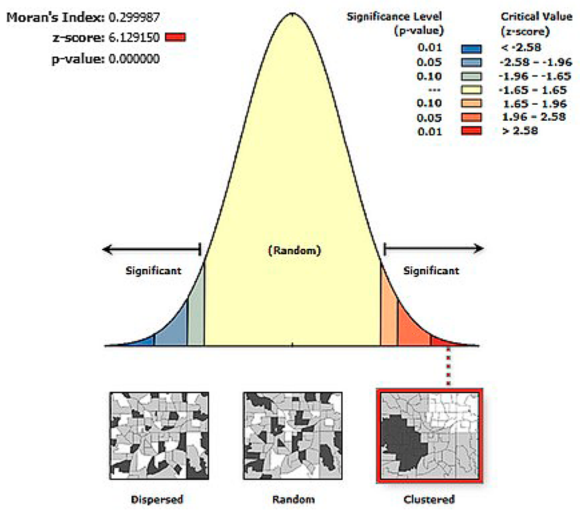
***. Correlation is significant at the 0.01 level (2-tailed).*

Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

in Bosnia and Herzegovina's total population. In the period from 2013 to 2020, the median age of the population of Bosnia and Herzegovina increased from 41.3 to 43.3 years, the vital index decreased from 0.869 to 0.618, the ageing coefficient increased from 14.3% to 17.8%, and the ageing index increased from 86.42% to 126.45% (BHAS, FZS, RZSRS, 2022). Table 2. depicts the relationship between fundamental demographic components and population ageing indicators in Bosnia and Herzegovina from 2013 to 2020.

The calculation of Spearman's correlation for Bosnia and Herzegovina's basic demographic components from 2013 to 2020 confirmed that there is a strong relationship between the ageing coefficient, the ageing index, and the components of natural population change and the vital index. Municipalities in Bosnia and Herzegovina with low vitality indexes and negative natural population change rates have higher ageing coefficient and ageing index values (Table 2).

According to *p*-values of 0.000 for Global Moran's I and 0.011 for Getis-Ord General G, which indicate that the null hypothesis is rejected, the spatial distribution of high and/or low values in the observed statistical ageing coefficient dataset in Bosnia and Herzegovina is more clustered than would be expected in random spatial processes. Furthermore, given the z-score of 6.129 for Global Moran's I, the likelihood that the spatial distribution of the ageing coefficient is a product of chance is less than 1.0%. Given the *z*-score of 2.537 for Getis-Ord General G, there is less than a 5% likelihood that the high-clustered pattern of the ageing coefficient could be the result of random chance. The clustering of the ageing coefficient in Bosnia and Herzegovina is therefore confirmed by Global Moran's I of 0.299 (z-score of 6.129; *p*-value of 0.000) and Getis-Ord General G value of 0.007 (*z*-score of 2.537; *p*-value of 0.011) (Figs. 1, 2).

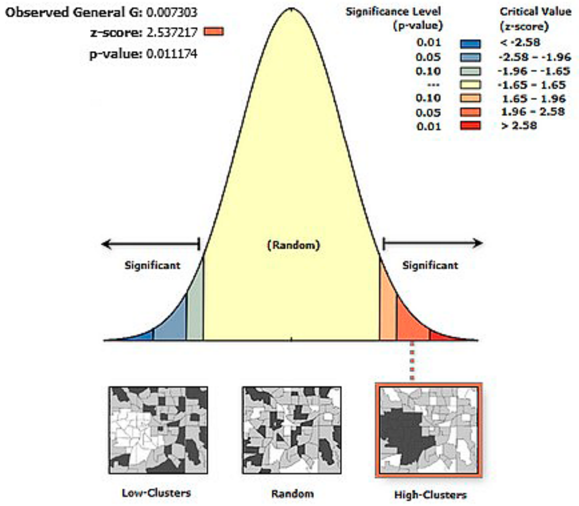


Given the z-score of 6.12915001206, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.299987
Expected Index:	-0.007092
Variance:	0.002510
z-score:	6.129150
p-value:	0.000000

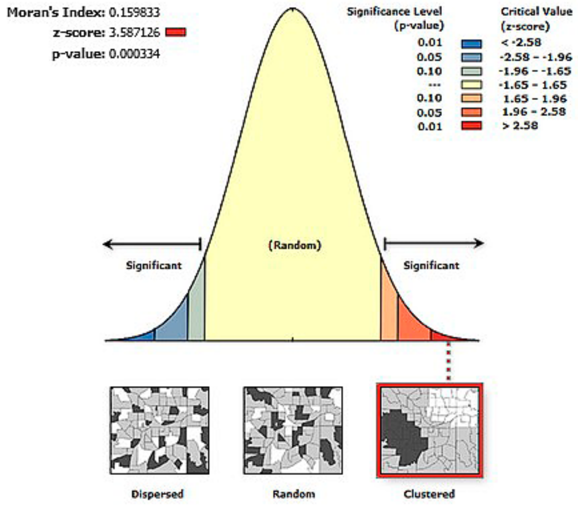
Figure 1. Global Moran's I final statistics and diagram for ageing coefficient in B&H, 2013-2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)



Given the z-score of 2.53721743911, there is a less than 5% likelihood that this high-clustered pattern could be the result of random chance.

General G Summary	
Observed General G:	0.007303
Expected General G:	0.007092
Variance:	0.000000
z-score:	2.537217
p-value:	0.011174

Figure 2. Getis Ord General G final statistics and diagram for ageing coefficient in B&H, 2013-2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)



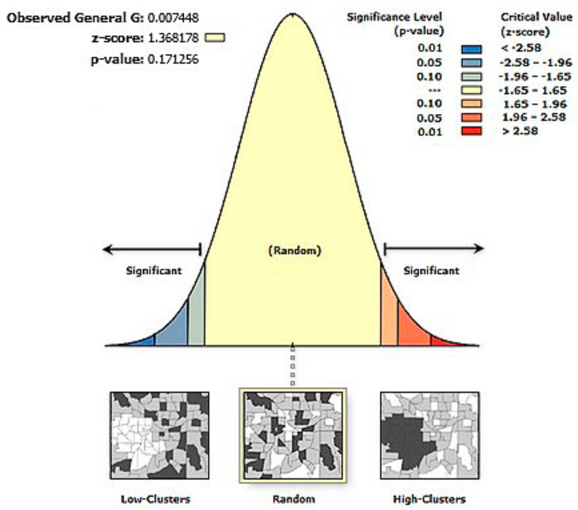
Given the z-score of 3.58712588968, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary	
Moran's Index:	0.159833
Expected Index:	-0.007092
Variance:	0.002165
z-score:	3.587126
p-value:	0.000334

Figure 3. Global Moran's I final statistics and diagram for ageing index in B&H, 2013-2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

A *p*-value of 0.000 for Global Moran's I indicate that the null hypothesis is rejected and that the spatial distribution of high and/or low values in the observed statistical ageing index dataset in Bosnia and Herzegovina is more clustered than would be expected in random spatial processes. Given the *z*-score of 3.587 for Global Moran's I, there is less than a 1.0% probability that this spatial distribution of ageing index values in Bosnia and Herzegovina could be the result of chance (Fig. 3). However, the spatial distribution of ageing index values does not appear to be significantly different from random based on the *z*-score of 1.368 and *p*-value of 0.171 for Getis Ord General G (Fig. 4).

Spatial clusters with high or low ageing coefficient and ageing index values in Bosnia and Herzegovina for the period 2013-2020 were identified using the local statistical indices Anselin Local Moran's I and Getis Ord Gi*. The statistical significance of local indices is based on the ratio of the *z*-score and *p*-value at the 0.01 significance level. For both datasets, the Anselin Local Moran's I of 0.299 for the age coefficient and 0.159 for the ageing index indicate moderate positive spatial autocorrelation. Positive autocorrelation means that the values in one area are similar to the values in the areas around it, while negative autocorrelation indicates outliers (Figs. 5 and 6, Table 3).



Given the z-score of 1.36817801632, the pattern does not appear to be significantly different than random.

General G Summary	
Observed General G:	0.007448
Expected General G:	0.007092
Variance:	0.000000
z-score:	1.368178
p-value:	0.171256

Figure 4. Getis Ord General G final statistics and diagram for ageing index in B&H, 2013-2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

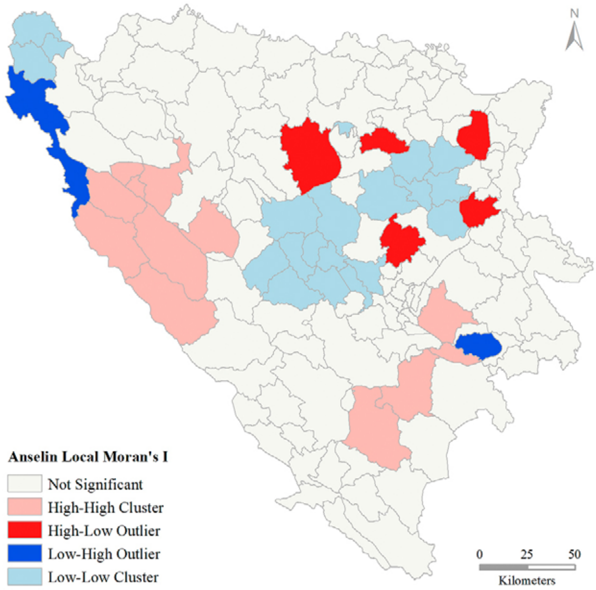


Figure 5. Spatial autocorrelation analysis of ageing coefficient in Bosnia and Herzegovina from 2013 to 2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

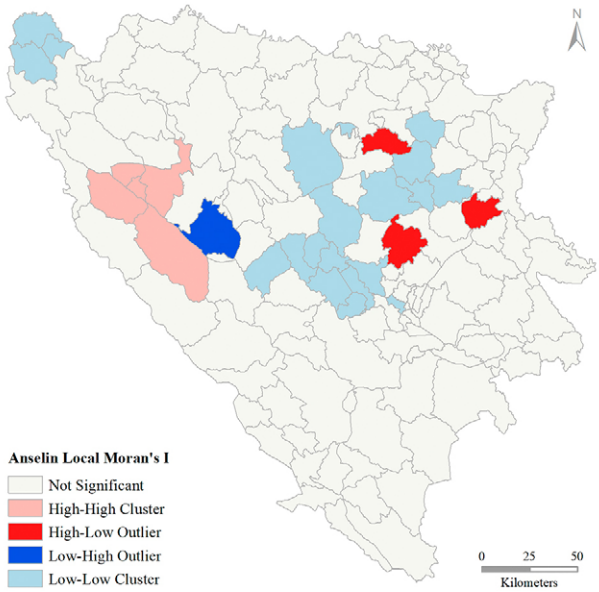


Figure 6. Spatial autocorrelation analysis of ageing index in Bosnia and Herzegovina from 2013 to 2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

Table 3. Local Moran's I statistics of ageing coefficient and ageing index in Bosnia and Herzegovina, 2013-2020

Municipality	Ageing Coefficient				Ageing index			
	Moran's I	z-score	p-val.	Type	Moran's I	z-score	p-val.	Type
B. Grahovo	2.601	1.749	0.046	HH	-	-	-	-
Banovići	1.114	2.077	0.006	LL	0.425	1.200	0.016	LL
Bihać	-0.694	-1.995	0.026	LH	-	-	-	-
Bugojno	0.588	1.740	0.032	LL	0.292	1.299	0.016	LL
Busovača	0.980	2.361	0.002	LL	0.469	1.707	0.002	LL
Bužim	2.194	2.208	0.006	LL	0.769	1.300	0.002	LL
Cazin	1.782	2.436	0.002	LL	0.630	1.572	0.002	LL
Drvar	2.634	3.363	0.004	HH	2.387	5.103	0.002	HH
Foča (FBiH)	0.978	2.336	0.018	HH	-	-	-	-
Fojnica	0.527	2.088	0.006	LL	0.315	1.506	0.006	LL
G. Vakuf	0.555	1.452	0.048	LL	-	-	-	-
Glamoč	2.591	4.820	0.002	HH	0.889	6.723	0.002	HH
Goražde	1.438	2.281	0.03	HH	-	-	-	-
Goražde	-0.218	-2.092	0.034	LH	-	-	-	-
Ist. Drvar	0.179	3.283	0.01	HH	4.738	2.160	0.032	HH
Kiseljak	0.487	1.876	0.022	LL	0.317	1.482	0.006	LL
Kladanj	0.668	1.474	0.046	LL	-	-	-	-
Livno	0.065	2.562	0.026	HH	-	-	-	-
Lopare	-0.314	-1.643	0.04	HL	-	-	-	-
Lukavac	0.284	1.900	0.016	LL	0.162	1.443	0.018	LL
N.Travnik	1.035	2.438	0.004	LL	0.462	1.526	0.004	LL
Nevesinje	0.456	2.128	0.018	HH	-	-	-	-
Pale (RS)	0.072	2.755	0.006	HH	-	-	-	-
Petrovac	1.294	1.778	0.05	HH	0.929	3.518	0.014	HH
Petrovo	-0.739	-1.733	0.028	HL	-0.231	-1.397	0.012	HL

Municipality	Ageing Coefficient				Ageing index			
	Moran's I	z-score	p-val.	Type	Moran's I	z-score	p-val.	Type
Ribnik	0.892	2.170	0.032	HH	0.415	2.823	0.016	HH
Šekovići	-0.258	-2.014	0.012	HL	-0.072	-1.404	0.024	HL
Šipovo	0.407	2.289	0.02	HH	-0.006	-2.375	0.046	LH
Teslić	-0.075	-1.995	0.02	HL	0.127	1.557	0.008	LL
Travnik	0.455	1.859	0.022	LL	-	-	-	-
Tuzla	0.011	1.590	0.042	LL	-	-	-	-
Usora	0.360	1.595	0.036	LL	-	-	-	-
V. Kladuša	2.301	2.249	0.002	LL	0.789	1.390	0.002	LL
Vareš	-0.572	-1.990	0.016	HL	-0.216	-1.531	0.004	HL
Visoko	0.536	1.693	0.03	LL	0.314	1.434	0.01	LL
Vitez	0.921	2.096	0.006	LL	0.445	1.451	0.004	LL
Zenica	0.599	2.401	0.002	LL	0.352	1.771	0.002	LL
Živinice	0.82	1.611	0.028	LL	0.328	1.161	0.05	LL

Results significant at the 0.05 level

Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

In certain municipalities in western, northwestern, eastern, northeastern, and central Bosnia and Herzegovina, the clustering of ageing coefficient values is identified. The municipalities of western Bosnia and Herzegovina identified in the high-high quadrant are Ribnik, Petrovac, Istočni Drvar, Drvar, Glamoč, Šipovo, Livno; the municipalities of northwestern Bosnia and Herzegovina located in the high-high quadrant are Velika Kladuša, Bužim and Cazin; in eastern Bosnia and Herzegovina, the municipalities of Pale-RS, Foča-FBiH, Kalinovik and Nevesinje are identified in the high-high quadrant. In the low-low quadrant in the central areas of Bosnia and Herzegovina, municipalities Zenica, Zavidovići, Travnik, Novi Travnik, Bugojno, Vitez, Busovača, Gornji-Vakuf-Uskoplje, Fojnica and Kiseljak are identified; in northeastern Bosnia and Herzegovina, municipalities Tuzla, Lukavac, Živinice, Kladanj and Banovići are identified in the low-low quadrant (Fig. 5, Table 3).

Clustering of ageing index values is identified in western, northwestern, northeastern, and central Bosnia and Herzegovina. The municipalities of western Bosnia and Herzegovina identified in the high-high quadrant are Ribnik, Petrovac, Istočni Drvar, Drvar and Glamoč. In the low-low quadrant in the central areas of Bosnia and Herzegovina, municipalities Zenica, Teslić, Bugojno, Novi Travnik, Vitez, Busovača, Visoko, Kiseljak, Fojnica, Kreševo and Novi Grad Sarajevo are identified; in northeastern Bosnia and Herzegovina, municipalities Zavidovići, Banovići, Živinice, Lukavac and Srebrenik are identified in the low-low quadrant; in the northwest of the country, the municipalities Velika Kladuša, Bužim and Cazin are identified in the low-low quadrant (Fig. 6, Table 3).

The Getis-Ord Gi* Index was used to identify high-risk and low-risk areas of population ageing in Bosnia and Herzegovina using values of the ageing coefficient and ageing index. Hot spots of the ageing coefficient with 99% confidence intervals were identified in western Bosnia and Herzegovina (municipalities of Istočni Drvar, Drvar, Bosansko Grahovo, Glamoč and Kupres-RS), eastern Bosnia and Herzegovina (Pale-RS, Foča-FBiH and Kalinovik) and 95% confidence intervals in western Bosnia and Herzegovina (municipalities of Petrovac, Ribnik, Šipovo and Livno). A cold spot cluster of ageing coefficient with a 99% confidence interval was identified in the northwestern parts of Bosnia and Herzegovina (municipalities Velika Kladuša, Bužim and Cazin), whereas cold spot clusters with a 95% confidence level were identified in central Bosnia and Herzegovina (municipalities Zenica, Travnik, Novi Travnik, Vitez, Bugojno, Fojnica, Kiseljak and Zavidovići), and northeastern Bosnia and Herzegovina (municipalities Lukavac, Živinice and Banovići) (Fig. 7). Hot spots of the ageing index with 99% and 95% confidence intervals were identified in western Bosnia and Herzegovina (municipalities Petrovac, Istočni Drvar, Drvar, Ribnik, Glamoč, Kupres-RS, Bosansko Grahovo and Šipovo) (Fig. 8, Table 4).

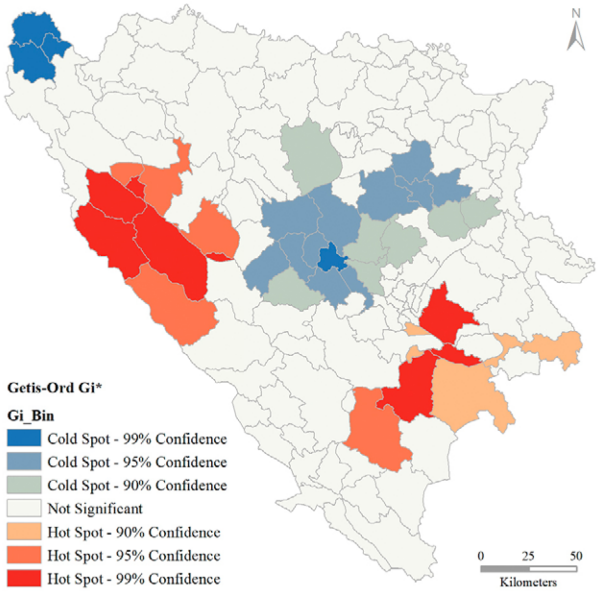


Figure 7. Getis-Ord G* analysis of ageing coefficient in Bosnia and Herzegovina from 2013 to 2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

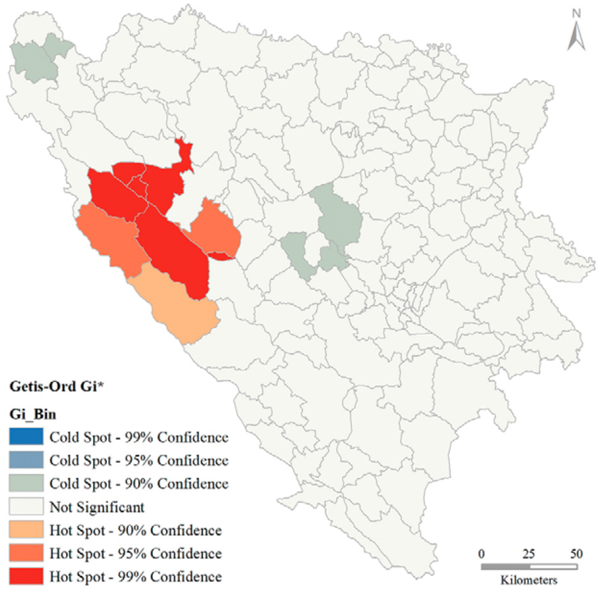


Figure 8. Getis-Ord G* analysis of ageing index in Bosnia and Herzegovina from 2013 to 2020
Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

Table 4. Getis Ord G* statistics for ageing coefficient and ageing index in Bosnia and Herzegovina, 2013-2020

Municipality	Ageing Coefficient			
	z-score	p-value	Gi-Bin	Confidence Level
B. Grahovo	2.923	0.003	Hot Spot	99%
Banovići	-2.324	0.02	Cold Spot	95%
Bugojno	-1.969	0.048	Cold Spot	95%
Busovača	-2.638	0.008	Cold Spot	99%
Bužim	-2.803	0.005	Cold Spot	99%
Cazin	-2.882	0.003	Cold Spot	99%
Drvar	3.842	0.000	Hot Spot	99%
Foča (FBiH)	2.596	0.009	Hot Spot	99%
Fojnica	-2.164	0.03	Cold Spot	95%
Glamoč	4.986	0.000	Hot Spot	99%
Ist. Drvar	3.137	0.001	Hot Spot	99%
Kalinovik	2.653	0.007	Hot Spot	99%
Kiseljak	-2.027	0.04	Cold Spot	95%
Kupres (RS)	2.835	0.004	Hot Spot	99%
Livno	2.243	0.024	Hot Spot	95%
Lukavac	-1.972	0.04	Cold Spot	95%
N. Travnik	-2.559	0.01	Cold Spot	95%
Nevesinje	2.160	0.03	Hot Spot	95%
Pale (RS)	2.832	0.004	Hot Spot	99%
Petrovac	2.349	0.018	Hot Spot	95%
Ribnik	2.513	0.011	Hot Spot	95%
Šipovo	2.410	0.015	Hot Spot	95%
Travnik	-2.024	0.04	Cold Spot	95%
V. Kladuša	-2.725	0.006	Cold Spot	99%

Municipality	Ageing Coefficient			
	z-score	p-value	Gi-Bin	Confidence Level
Vitez	-2.317	0.02	Cold Spot	95%
Zavidovići	-2.169	0.03	Cold Spot	95%
Zenica	-2.468	0.013	Cold Spot	95%
Živinice	-2.040	0.04	Cold Spot	95%
Municipality	**Ageing Index**			
	z-score	**p-value**	**Gi-Bin**	**Confidence Level**
B. Grahovo	2.338	0.019	Hot Spot	95%
Drvar	4.729	0.000	Hot Spot	99%
Ist. Drvar	4.287	0.000	Hot Spot	99%
Kupres (RS)	2.650	0.008	Hot Spot	99%
Petrovac	3.749	0.000	Hot Spot	99%
Ribnik	2.835	0.004	Hot Spot	99%
Šipovo	2.114	0.034	Hot Spot	95%

Results significant at the 0.05 level

Source: Author's calculation (BHAS, FZS, RZSRS, 2022)

Discussion

Numerous studies have been conducted all over the world on the extent of population ageing and the factors that contribute to it (Káčerová et al., 2022; Wang, 2020; Guan et al., 2020; Bucher, 2014). According to Wang (2020) and Bucher (2014), there are significant regional differences in population ageing. Therefore, studies indicating spatial inequalities and variations in population ageing in various countries and regions of the world have received special attention (Reynaud et al., 2018; Nikitović et al., 2016; Pina et al., 2013).

The spatial autocorrelation method is a particularly effective tool for identifying the spatial distribution, spatial disparities, and clustering of the population ageing process. This method can be used to determine a connection between numerous variables and provides insight into spatial disparities, such as whether or not there is a concentration of data in the area being studied (Kurek et al., 2021; Anselin, 1995; Ord & Getis, 1995). Therefore, the findings of studies based on spatial autocorrelation analysis can contribute to a better understanding of population ageing and the factors that influence this demographic phenomenon (Káčerová et al., 2022; Chen et al., 2019).

This study presents the results of a spatial analysis of population ageing in Bosnia and Herzegovina. The findings of this study confirmed that the spatial autocorrelation method is a particularly effective tool for identifying spatial disparities in Bosnia and Herzegovina's population ageing process. To determine spatial variations of ageing indicators in Bosnia and Herzegovina, the Global Morans I, Getis-Ord General G, and Anselin Local Morans I and Getis-Ord Gi* indexes of spatial autocorrelation were used. Both the ageing coefficient and the ageing index were discovered to cluster together in Bosnia and Herzegovina, as predicted by the Global Statistical Indexes. The clustering of ageing coefficient values was confirmed by local statistical indices in areas in western, northwestern, eastern, northeastern, and central Bosnia and Herzegovina. The clustering of the ageing index value, on the other hand, is identified in western, northwestern, northeastern, and central Bosnia and Herzegovina.

Population ageing is influenced by a variety of factors, including demographic, economic, social, environmental, health, and health care (Wan et al., 2022; Beard & Bloom, 2015; Almedia de Melo et al., 2010). Various studies have shown that numerous variables contribute to population ageing disparities in different areas of Bosnia and Herzegovina, with social, economic, and political factors being the most significant (Gekic et al., 2020; Gekic et al., 2021; Kadusic, Suljic, 2018). These factors have had a considerable impact on the demographic patterns and processes of Bosnia and Herzegovina's population at the beginning of the 21st century. For instance, these factors contributed to negative natural population changes and the emigration of young people (mainly between 20 and 40 years old). Consequently, these processes led to a decrease in the population's potential biodynamics and vitality (Kadusic et al., 2023). Bosnia and Herzegovina's age distribution and natural population change are significantly correlated. The study's findings demonstrated that the vital index and the components of natural population change, as well as the ageing index and the ageing coefficient, are strongly correlated. Higher ageing coefficient and ageing index values are found in Bosnia and Herzegovina municipalities with low vitality index values and negative natural population change rates.

Rural municipalities along the entity boundary line between administrative units of Bosnia and Herzegovina (the Federation of Bosnia and Herzegovina and the Republic of Srpska), and municipalities that were divided by the entity boundary are particularly affected by unfavorable demographic trends. Due to adverse socio-economic and political circumstances, these municipalities are losing some of their population. Economic factors are the primary causes of the continual emigration from Bosnia and Herzegovina. Young, highly educated individuals leaving the country is one issue that is particularly important. Emigration has a direct effect on the ageing of the population, natural changes in the population, and the decrease of population in Bosnia and Herzegovina. Areas with higher levels of economic development and employment opportunities attract younger people, increasing the younger population. Social factors such as cultural norms and values, improved access to healthcare, and higher quality of care all influence population ageing. Areas with higher environmental quality and better availability of natural resources mostly attract a younger population. All of the aforementioned factors are contributing to a decrease in the population's potential biodynamics and vitality, as well as negative natural population changes, an ageing population, and a large number of young people (mostly between the ages of 20 and 40) leaving the country. According to the Ministry of Security of Bosnia and Herzegovina (2019), the estimated number of emigrants who are originally from Bosnia and Herzegovina in foreign countries is at least 2 million, which is 53% of the total population in Bosnia and Herzegovina. According to World Bank estimates, that percentage is slightly lower and amounts to 44.5%, placing Bosnia and Herzegovina in 16th place in the world in terms of emigration rate in relation to the number of inhabitants in the country (out of a total of 214 countries and territories). Bosnia and Herzegovina is faced with a significantly higher rate of population emigration compared to the other countries in the region. With an emigration rate of 44.5%, it is significantly ahead of Serbia (18%), Croatia (20.9%), and Albania (43.6%). Emigration from Bosnia and Herzegovina is a continuous process, and its main causes are economic factors. One especially significant problem is the emigration of young, highly educated people. In Bosnia and Herzegovina, only one in eight young people (aged 16–24) is employed. A large number of young, highly educated people leave this country in search of better living and employment conditions (Ministry of Security, B&H, 2019). According to the laws of Bosnia and Herzegovina, a citizen who permanently settles abroad or who stays abroad for more than three months registers his residence in Bosnia and Herzegovina and the place of residence abroad at the competent diplomatic and consular representation of Bosnia and Herzegovina. However, if a citizen does not plan to stay in the country where he lives permanently, he is not required to register. According to data from the Agency of statistics in Bosnia and Herzegovina (2022), in the period from 2013 to 2020, 31,693 of its citizens emigrated from Bosnia and Herzegovina (an average of about 4,000 citizens emigrated annually). Of course, this does not represent the total number of people who left Bosnia and Herzegovina during the mentioned period, because the majority of people do not register their departure from the country. The population of Bosnia and Herzegovina mostly emigrates to Croatia, Slovenia, Germany, and Austria (Ministry of Security B&H, 2019; ANUBiH, 2019; FZS, 2020).

Ongoing depopulation processes are likely to have an effect on changes in the age structure of Bosnia and Herzegovina's population in the future. This will lead to an unfavorable demographic situation and population development. One of the primary issues facing Bosnia and Herzegovina's contemporary demographic development is a lack of population policy. As a result, this country's economic and social development must be strengthened. Therefore, it is important to define an adequate population policy that will revitalize Bosnia and Herzegovina's demographics.

The results of this study revealed spatial differences in Bosnia and Herzegovina's population ageing. This study's findings are a substantial contribution to demographic studies and a necessary condition for future demographic research, as well as the foundation for the planned demographic development of Bosnia and Herzegovina. Identifying the locations in Bosnia and Herzegovina that are losing population due to population ageing is a major contribution of the study that has been undertaken. The findings can be used to guide future demographic studies in Bosnia and Herzegovina, as well as to identify and further investigate variables that cause regional disparities in population ageing and other demographic variables.

Conclusion

The study emphasizes the use of spatial autocorrelation analysis as an effective method for identifying spatial disparities in population ageing and presents findings on the spatial distribution of ageing coefficient and ageing index values in Bosnia and Herzegovina. Global statistical autocorrelation indices revealed that autocorrelation was moderately positive. Local statistical indices confirmed a clustering of ageing coefficient values in western, northwestern, eastern, northeastern, and central Bosnia and Herzegovina. The ageing index values, on the other hand, are clustered in Bosnia and Herzegovina's central, western, northwestern, and northeastern areas. The study emphasizes that demographic, economic, social, environmental, and healthcare factors have the most significant impact on population ageing disparities in Bosnia and Herzegovina. All of these factors contributed to a decline in the potential biodynamics and vitality of the population, as well as to negative natural population changes and emigration. The ongoing processes of depopulation in Bosnia and Herzegovina are likely to have a negative impact on the population's age structure, leading to negative demographic trends. The results of this study are important for future research on population and are the basis for the planned population development of Bosnia and Herzegovina. Identifying areas with declining populations due to ageing is a significant contribution of the study and can be used to guide future demographic research and identify factors causing spatial demographic disparities.

References

Almeida de Melo, L., Macedo Ferreira, L.M.B., Marques dos Santos, M., & Costa de Lima, K. (2010). Socioeconomic, regional and demographic factors related to population ageing. *Revista Brasilera de Geriatria e Gerontologia* 20(4), 493-501. https://doi.org/10.1590/1981-22562017020.170004

Anselin, L. (1995). Local Indicators of Spatial Association - LISA. *Geographical Analysis* 27(2), 93-115. https://doi.org/10.1111/j.1538-4632.1995.tb00338.x

Anselin, L., & Getis, A. (1992). Spatial statistical analysis and geographic information systems. *The Annals of Regional Science* 26, 19-33. https://doi.org/10.1007/BF01581478

ANUBIH (2019). Emigration study Bosnia and Herzegovina. Systems Research Center, Book 4, Volume CLXXXII. Sarajevo: Academy of sciences and arts of Bosnia and Herzegovina. https://doi.org/10.5644/PI2019.182.00

BHAS (2022). Demography. Thematic Bulletin TB 02. Sarajevo: Agency for statistics of Bosnia and Herzegovina. Available at: https://bhas.gov.ba/ (23.11.2022)

BHAS (2022). Demography in Brčko Distrikt BiH. Godina XXI, No. 8. Sarajevo: Agency for statistics of Bosnia and Herzegovina. Available at: https://bhas.gov.ba/ (23.11.2022)

Beard, J.R., & Bloom, D.E. (2015). Towards a comprehensive public health response to population ageing. *Viewpoint* 358(9968): 658-661. https://doi.org/10.1016/S0140-6736(14)61461-6

Bucher, S. (2014). Selected Indicators of Population Ageing in the World: Trends, Impacts and Consequences. *Geographica Panonica* 18(2): 26-33. https://doi.org/10.5937/GeoPan1402026B

Chen, Y., Bouferguene, A., Shen, Y., & Al-Hussein, M. (2019). Difference analysis of regional population ageing from temporal and spatial perspectives: a case study in China. Regional Studies, *Volume* 53(6), 849-860. https://doi.org/10.1080/00343404.2018.1492110

d`Albis, H, & Collard, F. (2013). Age groups and the measure of population aging. *Demographic Research* 29(23), 617-640. http://doi.org/10.4054/DemRes.2013.29.23

FZS (2021). Statistical Yearbook 2021. Sarajevo: Institute for statistics of FB&H. Available at: http://fzs.ba/index.php/publikacije/statisticki-godisnjacilje-topisi/ (5.11.2022)

FZS (2020). Population Migration 2019. Statistical Bulletin 303. Sarajevo: Institute for statistics of FB&H. Available at: https://fzs.ba/wp-content/uploads/2020/02/Migracije-stanovnistva-2019-SB303.pdf (19.11.2022)

Gekic, H., Gekic-Bidzan, A., Miric, R., & Remenyi, P. (2020). Hidden geographies of population implosion in Bosnia and Herzegovina. *European Journal of Geography*, 11(2), 047-064. https://doi.org/10.48088/ejg.h.gek.11.2.47.64

Gekic, H., Bidzan-Gekic, A., Miric, R., & Dreskovic, N. (2019). Spatial differentiation of the age structure of a population in Bosnia and Herzegovina. *Proceedings of International Scientific Symposium "New trends in geography. Ohrid: Macedonian Geographical Society.*

Guan, D., Lei, L., & Han, Z. (2020). Spatial-Temporal Variation of Population Aging: A Case Study of China's Liaoning Province. *Hindawi*, 5436061. https://doi.org/10.1155/2020/5436061

Káčerová, M., Mládek, J., & Kusendová, D. (2022). Temporal and spatial analysis of population ageing and growing younger in Slovakia. *Folia Geographica* 64(1), 112-130. Available at: http://www.foliageographica.sk/unipo/journals/2022-64-1/638 (17.10.2022)

Kadusic, A., Smajic, S., Kunosic, S., & Smajic, N. (2023). Spatial Analysis of mortality in Bosnia and Herzegovina: a preliminary analysis. *Human Research in Rehabilitation* 13(1), 52-61. https://doi.org/10.21554/hrr.042306

Kadusic, A., & Suljic, A. (2018). Migration and Demographic Changes: The Case of Bosnia and Herzegovina. *European Journal of Geography* 9(4), 75-86. Available at: https://ojs.eurogeojournal.eu/index.php/egj/ article/view/52 (30.09.2022)

Kadusic, A., Suljic, A., & Smajic, N. (2016). Demographic ageing of population in Bosnia and Herzegovina: causes and consequences. *Revija za geografijo - Journal for geography* 11(1), 41-52. Retrieved from https://ff.um.si/publikacija/revija-za-geografijo-2016-11-1/ (15.09.2022)

Kerbler, B. (2015). Population Aging in Slovenia - A Spatial Perspective. *Acta geographica Slovenica* 55(2), 303-317. https://doi.org/10.3986/AGS.1885

Kurek, S., Wójtowitz, M., & Galka, J. (2021). Using Spatial Autocorrelation for identification of demographic patterns of Functional Urban Areas in Poland. Bulletin of Geography. *Socio-economic series* 52(2021), 124-144. https://doi.org/10.2478/bog-2021-0018

Kurek, S. (2003). The spatial distribution of population ageing in Poland in the years 1988-2001. Bulletin of Geography. *Socio-economic Series* 2, 65–75. Available at: https://apcz.umk.pl/BGSS/article/view/2525/2515 (17.10.2022)

Li, J., Han, X., Zhang, X., & Wang, S. (2019). Spatiotemporal evolution of global population ageing from 1960-2017. *BMC Public Health* 19, 127. https://doi.org/10.1186/s12889-019-6465-2

Mijic, N., & Ateljevic, J. (2018). Demographic Analysis Using Modern GIS Software Tools - Case Study of the Republic of Srpska (Bosnia and Herzegovina). In Hadžikadić, M., Avdaković, S. (eds) Advanced Technologies, Systems, and Applications II. IAT 2017. Lecture Notes in Networks and Systems, 28, 571-591. Springer, Cham. https://doi.org/10.1007/978-3-319-71321-2_51

Ministry of Security B&H (2019). *Bosnia and Herzegovina Migration Profile for the year* 2019. Sarajevo: Ministry of Security of Bosnia and Herzegovina.

Nikitović, V., Bajat, B., & Blagojević, D. (2016). Spatial patterns of recent demographic trends in Serbia (1961–2010). *Geografie* 121(4), 521-543. Available at: https://geografie.cz/media/pdf/geo_2016121040521.pdf (18.10.2022)

Ord, J.K., & Getis, A. (1995). Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. *Geographical Analysis* 27(4), 286-306. https://doi.org/10.1111/j.1538-4632.1995.tb00912.x

Pallant, J. (2011). *SPSS Survival Manual*. The 4th Edition. Allen&Unwin.

Pina, C., Conceição, P., & Breda-Vazquez, I. (2013). Ageing patterns: trends from Oporto's metropolitan region. Proceedings of CITTA 5th Annual Conference on Planning Research: Planning and Ageing - Think, Act and Share Age-Friendly Cities. Porto: University of Porto, Centre for territory, transports and environment. Available at: https://citta-conference.fe.up.pt/pdf/planning-and-ageing.pdf (21.10.2022)

Reynaud, C., Miccoli, S., & Lagona, F. (2018). Population Ageing in Italy: An Empirical Analysis of Change in the Ageing Index across Space and Time. *Spatial Demography* 6, 235-251. https://doi.org/10.1007/s40980-018-0043-6

RZSRS (2022). *Population estimates 1996-2021*. Banja Luka: Republic of Srpska Institute of Statistics. Available at: https://www.rzs.rs.ba/front/category/2/ (5.11.2022)

Wan, Q., Tang, Z., Pan, J., Xie, M., Wang, S., Yin, H., Li, J., Liu, X., Yang, Y., & Song, C. (2022). Spatiotemporal heterogeneity in associations of national population ageing with socioeconomic and environmental factors at the global scale. *Journal of Cleaner Production* 373(2022), 133781. https://doi.org/10.1016/j.jclepro.2022.133781

Wang, S. (2020). Spatial patterns and social-economic influential factors of population aging: A global assessment from 1990 to 2010. *Social Science & Medicine* 253, 112963. https://doi.org/10.1016/j.socscimed.2020.112963

Wu, L., Huang, Z., & Pan, Z. (2021). The spatiality and driving forces of population ageing in China. *PLoS ONE* 16(1), e0243559. https://doi.org/10.1371/journal.pone.0243559