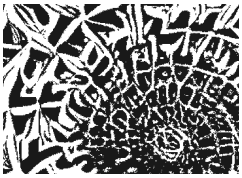

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CHANGES IN THE DEMOGRAPHIC DEPRESSION INDEX BY SETTLEMENTS OF CROATIA IN THE INTER--CENSUS PERIOD 2011–2021

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The long-term decrease in the total number of inhabitants, the ageing of the population and the social marginalisation of rural areas have caused negative demographic trends in almost the entire Croatia. The concepts of extinction, demographic depression, and demographic endangerment are most often associated with the phenomenon of demographic decline and economic decline in settlements. This paper compares the demographic depression index (I_{DD}) by settlements in Croatia for the 2011–2021 period, based on 11 demographic criteria defined by Mrđen and Marić (2018). The average I_{DD} value of all settlements in Croatia for 2011 was 2.22 (depressed/edge of demographic depression), while for 2021 it was 2.20. The largest share of settlements for both 2011 and 2021 belongs to demographically depressed area. The smallest share of settlements belongs to the category of extremely vital area. If the absolute change in the number of settlements by I_{DD} is observed, the largest increase was recorded in the demographically depressed area, and the largest decrease was recorded for the edge of demographic depression. The categories of vital and extremely vital areas did not register an increase. I_{DD} can be applied in the analysis, i.e., recognition of the demographic resources of an area with the aim of reducing inequality in socio-economic development, i.e. spatial imbalance.

Keywords: demographic depression, depopulation, ageing, Croatia

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INTRODUCTION

Today, demographic ageing is a widely discussed issue in Europe and worldwide, especially regarding the impact of an increasing share of the elderly population on the functional organisation of society (Stoica, 2011). The contemporary demographic development of the Republic of Croatia (RH) is characterised by a general depopulation that began in the second half of the 19th century in Lika and Gorski Kotar (Lajić & Klempić Bogadi, 2010). The long-term decrease in the total number of inhabitants – resulting from natural depopulation and a negative migration balance – along with population ageing and the socio-political and economic marginalisation of rural areas, has led to negative demographic trends throughout much of Croatia (Nejašmić, 2008). Terms such as "extinction" (Drobnjaković et al., 2014), "demographic depression" (Nejašmić, 1990; Mrđen & Marić, 2018; Marić et al., 2020), "demographic threats" (Zupanc, 2004; Vojnović, 2016), and "socio-demographic depressions" (Nejašmić, 1991; Nejašmić & Toskić, 2016) are frequently associated with demographic decline and the economic downturn of settlements in the Republic of Croatia.

Nejašmić and Toskić (2016, p. 203) describe socio-demographically depressed areas as regions that were *affected long ago by rural exodus and depopulation and were also heavily impacted by the direct consequences of war in the 1990*s. However, the ageing of rural populations is also characteristic of other post-socialist countries in Central and Eastern Europe (Guran-Nica & Rusu, 2015; Nejašmić & Toskić, 2016; Pantić & Živanović-Miljković, 2010; Traykov & Naydenov, 2015; Avdić & Avdić, 2023). Although demographic ageing is primarily a demographic phenomenon, its consequences extend to numerous aspects of society (Lutz et al., 2008). The direct and indirect trends resulting from it contribute to the decline of overall "human capital", which reflects the sustainability of a spatial unit (Filimon & Filimon, 2011) and serves as a driver of its socio-economic development (Nejašmić & Mišetić, 2010).

According to the latest census (2021), 195 settlements with no permanent residents and 2,933 settlements with populations between 1 and 100 inhabitants were recorded in the Republic of Croatia. Altogether, these 3,128 settlements cover an area of 19,732.68 km^2, which is just under 35% of Croatia's land area. Additionally, the fact that 2,907 settlements (43.02%) in Croatia have a population density of ≤ 20 inhabitants/km^2 highlights the extent of this demographic decline.

Within each territorial system, adaptation occurs based on its complex development potentials, often resulting in the migration of young people and the workforce from less favourable areas to more attractive ones (Filimon & Filimon, 2011). The direct consequences of this phenomenon frequently manifest

as demographic risks for predominantly rural, peripheral settlements, which, in the worst-case scenario, may lead to settlement extinction. This extinction is typically preceded by *population ageing*, defined as an increase in the proportion (%) of the elderly population (65+) within the total population. This process, influenced by extended life expectancy, youth emigration, and declining fertility rates, directly and indirectly contributes to demographic shifts (Čipin et al., 2014).

The long-term process of population ageing can lead to demographically depressed settlements, characterised by a dominant elderly population and an absence of younger and mature age groups (Mrđen & Marić, 2018). In such areas, the population typically exhibits a weakened educational and biological structure (Pejnović, 2004), which makes demographic 'revitalisation' challenging (Nejašmić & Mišetić, 2010; Mrđen & Marić, 2018; Marić et al., 2020). The consequences of this can vary, including economic impacts (labour shortages, economic imbalances, reduced consumption, inflation, and higher taxes on the working population), social effects (emigration and loss of central functions), and natural outcomes (changes in landscape structure) (Pantić & Živanović-Miljković, 2010; Mečev & Vudrag, 2012; Hospers & Reverda, 2014).

This issue has been increasingly discussed in geographical, and especially demographic, literature over recent decades (Filimon & Filimon, 2011; Nejašmić & Mišetić, 2010; Guran-Nica & Rusu, 2015; Mrđen & Marić, 2018) due to its relevance to community sustainability and vulnerability. Notably, the demographic resources (potential) of an area play a crucial role in mitigating socio-economic disparities and addressing spatial imbalances. Retaining and attracting new residents is essential for the economic success of rural communities. Rural areas experiencing population decline face several challenges, the most prominent being a reduction in the labour force and an increased demand for health services (Filimon & Filimon, 2011). The most significant contribution to the assessment of demographic resources in the Republic of Croatia was made by Nejašmić and Mišetić (2010), who developed a specific indicator – the index of demographic resources (I_{DER}) – based on 15 variables. Mrđen and Marić (2018) subsequently de-rived a synthetic index of demographic depression based on 11 demographic criteria.

The main objectives of this research are:

1) Derive the I_{DD} based on 11 defined criteria for the year 2021
2) Compare the spatial distribution of I_{DD} by settlements between the two population censuses (2011 and 2021)
3) Determine the most vital and demographically depressed settlements in Croatia.

MATERIALS AND METHODS

Demographic depression index (I_{DD})

Definition of the criteria

In defining the index of demographic depression (I_{DD}), the methodological approach described by Mrđen and Marić (2018) was applied, with modifications made to the criteria standardisation method. In Mrđen and Marić (2018), criteria were classified using the natural breaks (Jenks) method, followed by a manual adjustment of the third class to align with the Croatian average. However, this approach is not applicable for comparing I_{DD} between census periods or across different countries. Using the Jenks method would result in varying class break values for the I_{DD} models derived for 2011 and 2021, making comparisons impossible. Therefore, classification was conducted using the decision-maker method, proposing fixed class boundaries for each criterion, consistent across both years (2011 and 2021).

The first three criteria (for the intercensal periods 2001–2011 and 2011–2021) were selected as key demographic criteria impacting the final balance, that is, the increase, stagnation, or decrease of the total population (Wertheimer-Baletić, 2017). Criteria ranging from 4 to 10 were chosen due to their recognised importance in population ageing analysis and their precise indication of ageing trends within a given area.

1) As – Increase/decrease in the number of inhabitants during the intercensal period
2) Pr – Natural change in the intercensal period
3) Mb – Migration balance in the intercensal period
4) Pd – Average age
5) Ins – Age index
6) Post_0-14 – Percentage of the population aged 0-14
7) Post_65 – Percentage of the population aged 65 and over
8) Post_80 – Percentage of the population aged 80 and over
9) Coef_dov_st – Coefficient of age dependence of the elderly
10) Post75_u65 – Percentage of the population aged 75 and over within the age group of 65 and over
11) Number of inhabitants – Corrective factor

From a methodological perspective, it is necessary to clarify the use of the seventh and eighth criteria. These criteria provide a deeper insight into the intensive demographic ageing of the population, particularly evident from the share of those aged 80 and over. According to the 2011 census, this age group constituted 3.9% of Croatia's population, rising to 5.5% (just over 200,000 people) in 2021. Furthermore, the extent of ageing becomes especially apparent when comparing this group

to the number of children under five years of age at the settlement level. In the latest census, it appears that in as many as 46% of settlements (or 4,070 out of a total of 6,562, excluding those without inhabitants), the population aged over 80 exceeds that of children under five. This trend indicates a significantly weakened or absent demographic base, suggesting that many settlements are at risk of depopulation. Consequently, criterion eight was essential in deriving the I_{DD}.

In calculating the ninth criterion (coefficient of age dependence), the age categories of the working-age population, defined here as individuals aged 15-64 years, and the elderly population, aged 65+ years, were used. Although it is documented that age-dependence criteria and its variations have certain limitations (Koettl, 2015), it was included in the analysis. The decision to use the age 65+ category was based on the current retirement age for pensioners in Croatia (Špiljak, 2023), making this age threshold appropriate for comparison with the 2011 data. In future research, this criterion will need to be modified to more accurately reflect the labour market situation, as static ratios do not account for behavioural changes, increasing life expectancy, or evolving retirement policies.

The results of the 2011 and 2021 censuses, along with vital statistics data for analysing natural trends, were used, and the migration balance was calculated using the vital statistics method.

Defining the territorial basis of I_{DD}

The official borders of Croatia's 6,756 settlements from 2011 were used as the basis for displaying the index of demographic depression (I_{DD}). According to the 2021 census, 27 new settlements were created, while 26 former settlements ceased to exist. Table 1 shows the changes in settlement structure between the two censuses (2011 and 2021).

Most of the listed settlements were established within the three years leading up to the 2021 census (from 2019). Of these 27 new settlements, three have no inhabitants, two have fewer than 10 inhabitants, and six have fewer than 100 inhabitants. Since there is no data from the 2011 census for these 27 settlements, and data from the intercensal period (e.g., 2011–2021) are needed to calculate the first three criteria, it was not possible to calculate values for these criteria. In such cases, these settlements were excluded from the analysis. For this reason, the I_{DD} was based on the 2011 settlements, without the new settlements as separate elements. For example, in the 2021 I_{DD} model, Podstrana is represented as a single settlement rather than divided into its ten new subdivisions. Conversely, the settlement of Cerovljani, created by merging Donji and Gornji

Cerovljani, is shown as one settlement in 2021. By choosing the 2011 settlement boundaries as the basis for I_{DD} display, data from the 2011 census for Donji and Gornji Cerovljani (both total and by five-year age groups) were aggregated to ensure comparability with the single settlement of Cerovljani from 2021. Although the 2021 settlement base was not used to display the I_{DD}, no residents were 'left out' of the analysis.

TABLE 1
Changes in the structure of settlements between the two censuses (2011 and 2021)

New settlements in the 2021 census				Settlements that are not in the 2021 census			
ID	County	City/ Municipality	Settlements	ID	County	City/ Municipality	Settlements
76651	SM	Hrvatska Dubica	Cerovljani	2348	I	Buzet	Benčići
76660	LS	Novalja	Jakišnica	5118	KZ	Zabok	Bregi Zabočki
76678	LS	Novalja	Dubac-Varsan	13161	SM	Hrvatska Dubica	Donji Cerovljani
76686	LS	Perušić	Varoš	16004	I	Buzet	Duričići
76694	SD	Milna	Podhume	20338	SM	Hrvatska Dubica	Gornji Cerovljani
76708	SD	Milna	Bobovišća na moru	21911	KZ	Zabok	Grabrovec
76716	ZD	Tkon	Ugrinić	30236	KA	Rakovica	Korana
76724	ZD	Jasenice	Maslenica	30686	I	Buzet	Kosoriga
76732	ZD	Jasenice	Rovanjska	31038	I	Buzet	Kotli
76759	VA	Jalžabet	Poduzetnička Zona Jalžabet	31801	I	Buzet	Kras
76767	SD	Podstrana	Podstrana – Žminjača	32514	I	Buzet	Krkuž
76775	SD	Podstrana	Podstrana – Sita	32760	I	Buzet	Krti
76783	SD	Podstrana	Podstrana – Strožanac Donji	33120	CZ	Zagreb	Kućanec
76791	SD	Podstrana	Podstrana – Strožanac Gornji	37826	I	Buzet	Mala Huba
76805	SD	Podstrana	Podstrana – Miljevac	39667	I	Buzet	Martinci
76813	SD	Podstrana	Podstrana – Grljevac	47333	I	Buzet	Pengari
76821	SD	Podstrana	Podstrana – Grbavac	49379	I	Buzet	Podkuk
76830	SD	Podstrana	Podstrana – Sv. Martin	49549	I	Buzet	Podrebar
76848	SD	Podstrana	Podstrana – Mutogras	49719	SD	Podstrana	Podstrana
76856	SD	Podstrana	Gornja Podstrana	55255	I	Buzet	Rimnjak
76864	SD	Marina	Sevid na moru	57673	I	Buzet	Sirotići
76872	SD	Marina	Ljubljeva	59137	I	Buzet	Sovinjsko Polje
76899	CZ		Vugrovec	61646	I	Buzet	Sušići
76902	ZD	Sv. Filip i Jakov	Babac	71463	CZ	Zagreb	Vuger Selo
76929	ZD	Pašman	Barotul	71498	CZ	Zagreb	Vugrovec Donji
76937	SD	Zadvarje	Dubci	74829	PG	Rijeka	Bakar
76643	KZ	Zabok	Bregi Zabočki Donji				

SM – Sisak-Moslavina, LS – Lika-Senj, SD – Split-Dalmatia, CZ – City of Zagreb, ZD – Zadar, I – Istria, KZ – Krapina-Zagorje, KA – Karlovac, PG – Primorje-Gorski Kotar
Source: *Promjene u teritorijalnom ustroju Republike Hrvatske u razdoblju 2011.–2021.* DZS / Prostorni statistički registar. (*Changes in the territorial structure of the Republic of Croatia in the period 2011–2021,* SSO / Spatial Statistical Register).

Criteria standardisation

The criteria defined and derived for 2011 were obtained from the database by Mrđen and Marić (2018). Consequently, it was necessary to calculate all criteria for 2021 using updated data. After organising the database and calculating each criterion, they were standardised using the decision-maker method, re-

presenting a methodological modification relative to Mrđen and Marić (2018). Standardisation is essential for comparing criteria expressed in different units (e.g., ‰, population, %, etc.) on a uniform numerical scale (Marić et al., 2021). The standardisation was applied on a scale from 1 to 5, with each class assigned a specific meaning:

(5) extremely vital area
(4) vital area
(3) an area on the edge of demographic depression
(2) demographically depressed area
(1) extremely demographically depressed area
Category (0) represents extinct settlements for 2011 and 2021.

Class boundaries for each criterion were defined using the decision-maker standardisation method (Domazetović et al., 2019; Pohekar & Ramachandran, 2004). Since, to the best of the author's knowledge, no predefined class boundaries for the selected criteria exist in the literature to indicate whether a certain area is demographically 'vital' or 'depressed,' it was decided to propose the first such classification. While class definitions could also be determined using the natural breaks method (Jenks' method), this approach would result in different class limits for the 2011 and 2021 criteria. The reason is that the Jenks method seeks to minimise the average deviation of values within each class from their respective means, while maximising the deviation between classes. This would lead to different classifications for model 1 (I_{DD} 2011) and model 2 (I_{DD} 2021), making comparison and change analysis impossible. If the Jenks method were used for the 2011 criteria, and these class breaks were then applied to 2021, comparison would be possible. However, this approach would risk mismatches between the numerical values of a criterion and its thematic meaning. For example, Jenks' method, given Croatia's demographic challenges, might classify an age of 37 as 'extremely vital', which is clearly inaccurate. Therefore, this paper proposes custom class boundaries that appropriately describe the thematic meanings (e.g., 'vital', 'depressed') for each criterion. This approach, representing a modification of the Mrđen and Marić (2018) methodology, enables a valid comparison of I_{DD} between the two censuses. The absence of predefined class boundaries reflecting these thematic categories (e.g., 2 – *vital*, 4 – *demographically depressed*, 5 – *extremely demographically depressed*) highlights the contribution of this proposal, which future research may adapt based on new demographic insights. Consistent class boundaries for both periods studied (2011 and 2021) are essential.

Among the settlements classified as (1) extremely depressed areas, those that are even more socio-economically vulnerable

due to limited or absent basic central functions can be highlighted. Terms often associated with the socio-economic vulnerability of such settlements include 'remoteness', 'accessibility', and 'marginalisation' (Alsnih & Hensher, 2003; Taylor & Susilawati, 2012; Hasan et al., 2017; McLean et al., 2007).

TABLE 2
Classification of selected criteria according to standardised categories

Categories	As	Pr	Mb	Pd	Ins	Post_0-14
5	> 10.0	> 5.0	> 5.0	up to 30.0	up to 20.0	>25.0
4	2.1 - 10.0	2.1 - 5.0	2.1 - 5.0	30.1 - 35.0	20.1 - 50.0	20.1 - 25.0
3	- 2.0 up to +2.0	- 2.0 up to +2.0	- 2.0 up to +2.0	35.1 - 40.0	50.1 - 90.0	10.1 - 20.0
2	-2.1 up to -10.0	-2.1 up to -5.0	-2.1 up to -5.0	40.1 - 50.0	90.0 - 140.1	5.1 - 10.0
1	< - 10.0	< - 5.0	< - 5.0	>50.0	> 140.0	up to 5.0

Categories	Post_65	Post_80	Coef_dov_s	Post75_u65	No. of inhabitants
5	up to 5.0	up to 2.0	up to 5	up to 25.0	> 5000
4	5.1 - 10.0	2.1 - 4.0	5.1 - 20	25.1 - 30.0	2001-5000
3	10.1 - 20.0	4.1 - 10.0	20.1 - 40	30.1 - 40.0	401-2000
2	20.1 - 30.0	10.1 - 15.0	40.1 - 50	40.1 - 50.0	51-400
1	> 30.0	> 15.0	>50	> 50.0	0-50

(5) – extremely vital area; (4) – vital area; (3) – an area on the edge of demographic depression; (2) – demographically depressed area and (1) – extremely demographically depressed area

RESULTS AND DISCUSSION

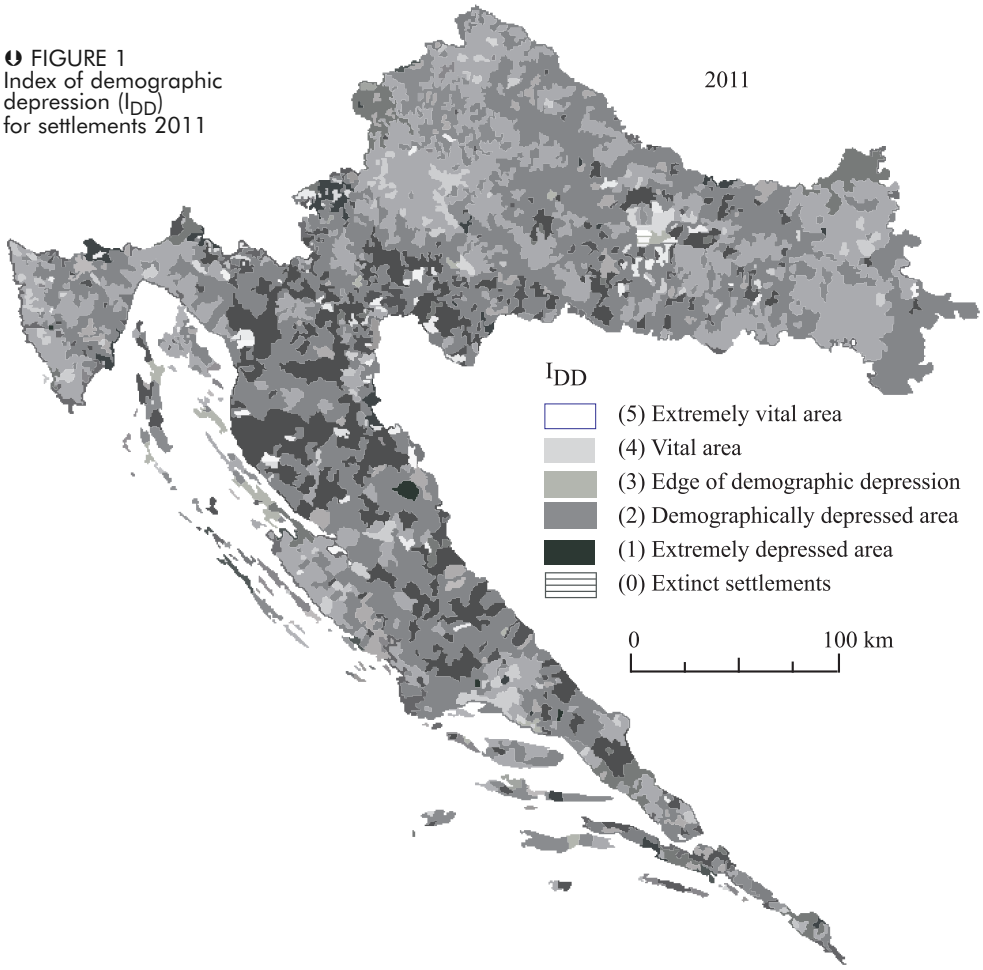
Index of demographic depression (I_{DD}) 2011

Figure 1 shows the index of demographic depression (I_{DD}) for 2011. In 2011, based on all 11 criteria, a total of 44 settlements exhibited characteristics of an extremely depressed area (category 1). Among these, four settlements had only one enumerated inhabitant. These settlements are: Bijeli Klanac, Valići, Zut, and Bucalovići. They can be considered the most depressed settlements in Croatia in 2011.

The settlement of Valići is located in the municipality of Jelenje (Primorje-Gorski Kotar County) on the eastern bank of the Rječina River, near the reservoir of the artificial Lake Valići, which was created by the construction of the hydroelectric power plant (HPP) that has been generating electricity since 1968. The houses of the Valići settlement are mostly submerged under the lake, and the resident listed in 2011 is one of the few whose house was not flooded (URL 1). Bijeli Klanac is a settlement in the municipality of Krnjak, Karlovac County. According to the 1991 census, Bijeli Klanac had 31 inhabitants, all of Serbian nationality (URL 2). The village of Zut is part of the municipality of Dvor (Sisak-Moslavina County). According to the 1991 census, Zut had 145 inhabitants, 142 of whom (97.93%) were of Serbian nationality (URL 3). Bucalovići is a village in the municipality of Višnjan, Istria County. In

the 1991 census, it had 16 inhabitants, half of whom were of Italian nationality (URL 4). Bucalovići is recognised on the Geografija.hr portal as one of the most demographically threatened settlements in Istria (URL 5).

FIGURE 1
Index of demographic depression (I_{DD}) for settlements 2011



Source: Calculated in Mrđen and Marić (2018); modified according to the defined classification

The category of *extremely vital* area (5) for 2011 includes 12 settlements. Out of those 12 settlements, not a single settlement has the characteristics of an extremely vital area according to all 11 criteria (5). Based on the I_{DD}, the four demographically most vital settlements in Croatia for 2011 are Parag, Piškorovec, Krničari and Dedin. Parag and Piškorovec are the only two settlements in Croatia that are inhabited exclusively by the Roma population. The settlement of Parag was separated from the settlement of Trnovec in the municipality of

Nedelišće in 2005. In the same year, the Piškorovec district was separated from the Držimurec settlement in the municipality of Mala Subotica. According to the 2011 census, Parag had 1,187 inhabitants, while Piškorovec had 672 inhabitants (Šlezak, 2022). Dedin is a settlement in the town of Delnice in the Primorje-Gorski Kotar County. According to the 2011 census, it had 93 inhabitants. The City of Delnice relocated a small number of families who did not have accommodation in the town to the area of the Dedin settlement and equipped the land with containers and caravans (URL 6). In the document *Action Plan of the City of Delnice for the implementation of the national strategy for the inclusion of Roma for 2017–2020,* it is stated that 13 Roma live in Dedin I and Dedin II (parts of the Dedin settlement) out of 93 inhabitants. However, it is stated that a certain number of people do not want to declare themselves as Roma, even though they belong to that group (URL 6). The village of Krničari is located in the Municipality of Žminj, in the County of Istria. According to the 2011 census, it had 96 inhabitants, of which 25% belong to the Albanian national minority.

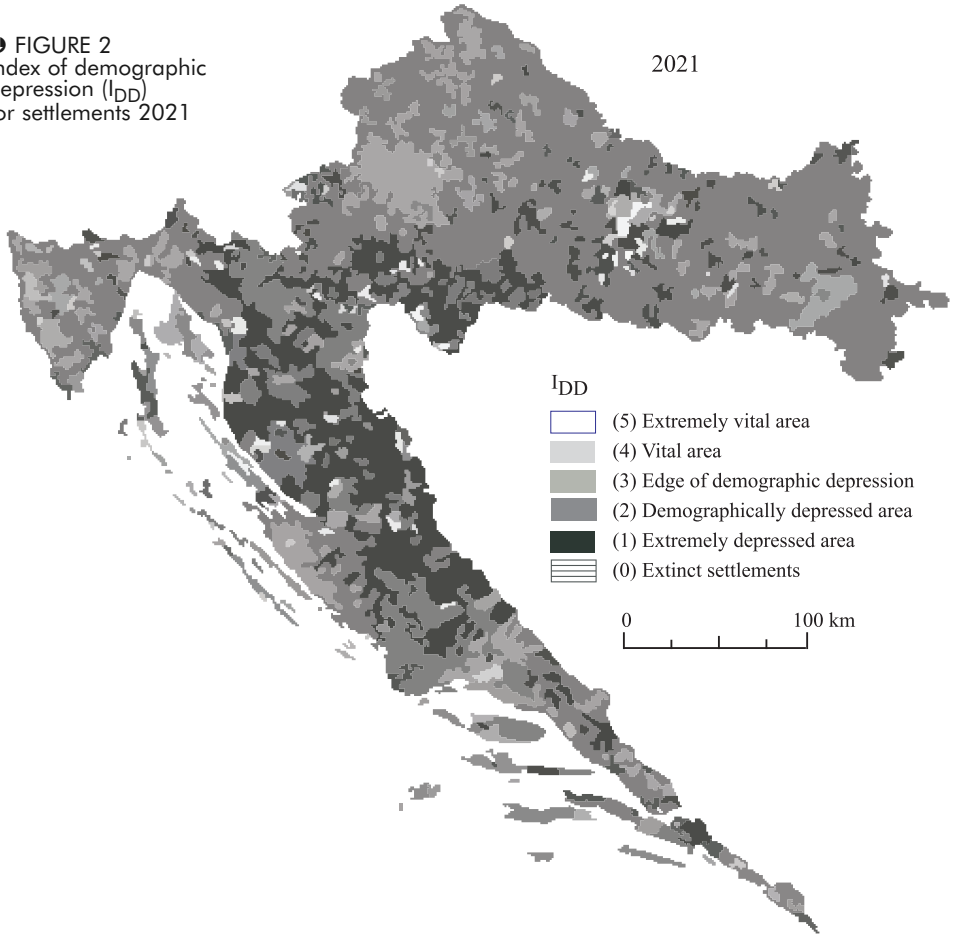
Index of demographic depression (I_{DD}) 2021

Figure 2 shows the index of demographic depression (I_{DD}) for 2021. In that year, based on all 11 criteria, a total of 83 settlements fell into the category of extremely depressed areas (category 1). Among these, eight settlements had only one enumerated inhabitant. These settlements – Bandino Selo, Ponor Koreničk, Donja Stranica, Kraljevo Selo, Štirkovac, Kamenski Vučjak, Mala Kosa, and Tihočaj – can be considered the most demographically depressed settlements in the Republic of Croatia in 2021.

The village of Bandino Selo is located in the town of Slunj, Karlovac County. According to the 2011 Census, the settlement had six inhabitants, most of whom were of Serbian nationality. Ponor Koreničk, part of the Plitvička Jezera Municipality in the Lika-Senj County, had one resident in the 2021 census, thus not classified as an 'extinct settlement'. A short film titled *Lika baš danas – ličko selo Koreničk Ponor koje je izumrlo* was made about Koreničk Ponor, highlighting its near-extinct status (URL 7). Kraljevo Selo is situated in the Bosiljevo Municipality, Karlovac County, and had 41 inhabitants in the 1991 census but only four in 2001. This sparsely populated area, characterised by small, fertile plots scattered along slopes, has many small settlements due to its unique inheritance patterns (Turk et al., 2022). Furthermore, wartime conditions significantly reduced the population in Bosiljevo and other municipalities in the Karlovac County (Prostorni plan uređenja Općine Bosiljevo, 2018). This applies also to Štrikovac and Mala

Kosa in Barilović Municipality, which each had fewer than 20 residents in 1991, all of Serbian nationality. Kamenski Vučjak, located in the Brestovac Municipality, Požega-Slavonia County, had 89 residents in 1991 and is listed among the settlements destroyed in PSC during the Homeland War (URL 8). Tihočaj, in Jastrebarsko, Zagreb County, within the Žumberak-Samobor Hills Nature Park, experienced significant emigration in the 1950s (URL 9).

FIGURE 2
Index of demographic depression (I_{DD}) for settlements 2021



The category of *extremely vital* area (5) for 2021 includes five settlements. Of these five settlements, not a single settlement has the characteristics of an *extremely vital* area according to all 11 criteria (5). According to the I_{DD}, the four most demographically vital settlements in Croatia based on the data for 2021 are Piškorovec, Parag, Donje Vratno-dio, Dedin and Veliko Polje. Piškorovec, Parag and Donje-Vratno are part of the settlements that were recognised as the most vital settlements. However, the settlements of Piškorovec and Parag have

a slightly lower I_{DD} in 2021 compared to 2011. In 2021, both settlements had an I_{DD} of 4.45 (*vital/extremely vital area*), while in 2021 Parag had 4.82 (*extremely vital area/vital*), and Piškorovec had 4.64 (*extremely vital area/vital*). So, although the settlements did not change the I_{DD} category, there was a slight decline in vitality, i.e. an increase in demographic depression. Šlezak (2022) writes about this in the paper *Where have the Roma gone? Reflecting on the first results of the 2021 census on the example of a comparison of the natural and total population trends of the Roma settlements of Parag and Piškorovec in Međimurje County*. He concludes that the 2021 census recorded much fewer inha-bitants than expected and there are two possible reasons for this: 1) the population census was not fully conducted in these settlements and 2) the occurrence of intensive emigration from the largest Roma settlements.

Veliko Polje is a suburban residential area within the City of Zagreb. The settlement is characterised by good connections with Zagreb and Velika Gorica. It is located along important traffic routes from Zagreb to Sisak and Posavina, and it is about 9 km from the centre of Zagreb by air, or about 4.5 km from Velika Gorica. Despite the administrative border, the settlement of Veliko Polje is a functionally unique area with the settlement of Velika Mlaka. Veliko Polje was created in the 1980s as a new, planned residential part of the settlement, while public and social infrastructure was planned in Velika Mlaka as an older settlement. Recently, new, mostly service facilities have started to be built in Veliko Polje. However, residents are still mostly forced to use central-local functions in Velika Mlaka (kindergarten, school, church, health centre, etc.) (ZZPUGZ, 2019; URL 10).

The map of changes in the I_{DD} for Croatia (Figure 3) indicates that the intensification of demographic depression is spatially present in almost the entire country, that is, even the largest settlements are not spared.

The average value of the I_{DD}[1] for the settlements in Croatia for 2011 is 2.22 (*depressed/on the verge of demographic depression*). The average value of the I_{DD} for 2021 is 2.20. According to the rate of decline of the I_{DD} of Croatia and the retention of the existing values of the calculated demographic parameters, Croatia will be without a population in 1100 years or 3123 years. According to the UN, which published the 'extinction map' of humanity, Croatia will die out by the year 3300 at the latest. The estimates were based on the reproduction coefficient of the population (Mrvoš Pavić, 2011).

Changes in I_{DD} categories

Table 3 presents the number of settlements according to the defined categories of I_{DD}. Based on data for 2011 and 2021, most settlements fall within the '*depressed area*' category (2). As expected, the smallest proportion of settlements is classified as

'*extremely vital area*' (5). Observing the absolute change in the number of settlements across categories, the largest increase was seen in the '*depressed area*' category (2), while the largest decrease occurred in the '*edge of demographic depression*' category (3), as category (3) shifted towards more demographically depressed areas (1 and 2). The categories of '*vital*' (4) and '*extremely vital*' (5) did not record any increase.

TABLE 3
Number of settlements based on I_{DD} for 2011 and 2021

Categories	Meaning	2011	%	2021	%	(2021 – 2011)
5	Extremely vital	12	0.18	5	0.07	-7
4	Vital area	327	4.84	138	2.04	-189
3	Edge of demographic depression	2117	31.34	1385	20.50	- 732
2	Depressed area	3096	45.83	3638	53.85	542
1	Extremely depressed area	1054	15.60	1393	20.62	339
0	Extinct settlements	150	2.22	197	2.92	47
	Total	6756	100.0	6756	100.0	

Figure 3 shows the spatial distribution of changes in I_{DD} categories by settlement.

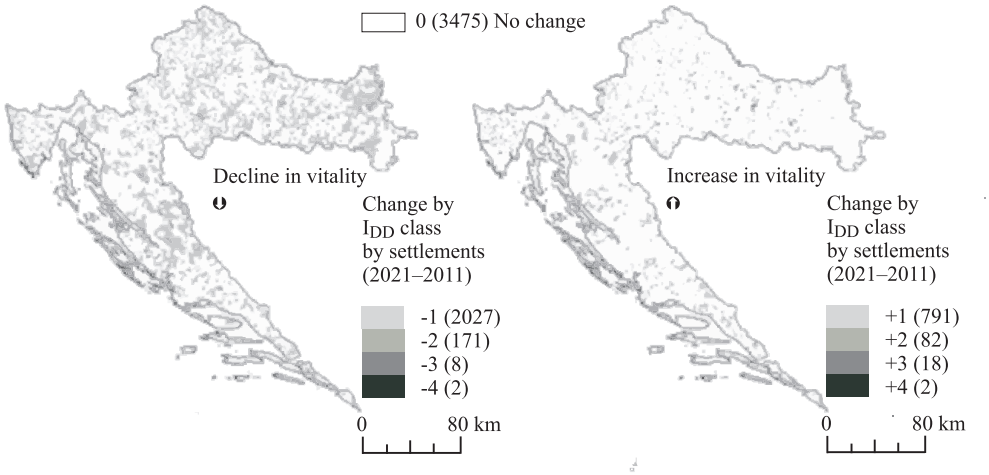


FIGURE 3
Change in the categories of settlements based on the I_{DD} 2011–2021

By applying the I_{DD}, settlements that are expected to become extinct in the next population census, that is, potential new 'dead settlements', have been identified. Of the 1,393 settlements that fall into the category of extremely depressed area (1), 53^2 settlements were singled out that meet two criteria:

1) in all 11 evaluated criteria, they are in the category of *extremely depressed area* (1)
2) have ≤ 10 inhabitants.

The average age in them is 73.35 years.

By applying the I_{DD}, the settlements expected to be the *most demographically vital* in Croatia were identified. Since no settlement in Croatia meets the criteria for category 5 (extreme-

ly vital) across all 11 variables, the following two criteria were used to single out certain settlements:

1) Belonging to the 'extremely vital' category (5).

2) Having a population of ≤ 500 inhabitants.

There are three such settlements in Croatia (Parag, Piškorovec, and Veliko Polje), with an average age of 24.92 years.

Changes in I_{DD} categories based on counties

The changes in the I_{DD} category for Croatia (Figure 3) show that the intensification of demographic depression is widespread across nearly the entire country, affecting even the largest settlements. Although it is difficult to pinpoint the areas with the most severe negative changes, the regions of Lika and Bukovica (specifically, the municipalities of Gračac, the town of Obrovac, and the municipality of Donji Lapac) and Eastern Slavonia (including the municipality of Bilje, the City of Osijek, and the municipalities of Darda and Kneževi Vinogradi) stand out. These areas have seen increases in I_{DD} due to a complex interplay of social and natural-geographical factors. Eastern Slavonia, traditionally reliant on agriculture, and Lika and Bukovica, dependent on animal husbandry, have faced declining trends in recent years. For example, between 2016 and 2018, the number of agricultural holdings in the Osijek-Baranja County decreased by 2,796, from 12,078 to 9,282, and in the Vukovar-Srijem County, the number dropped by 1,035 holdings (DZS, 2023).

Furthermore, these regions still suffer from the lingering effects of the war. The areas of Donji Lapac and Gračac, in particular, are relatively isolated, with challenging terrain. Their proximity to the Bosnia and Herzegovina (BiH) border has not proven advantageous; the bordering area of Bosanski Grahov is recognised as the most geographically marginalised area in Bosnia and Herzegovina (Marić & Avdić, 2023). These factors exacerbate economic hardship and limit business opportunities, leading to youth emigration and an increase in I_{DD}. This trend is especially pronounced in Eastern Slavonia, which, unlike Lika and Bukovica, had a larger base of young people available to migrate.

Figure 4 shows the change in I_{DD} categories by county. The counties are ranked according to the proportion of settlements that experienced a negative change, indicating a decline in vitality or intensification of demographic depression according to the proposed methodological model. In the Vukovar-Srijem County, no settlement showed an increase in demographic vitality. Additionally, the counties that experienced the greatest decline in vitality, or an intensification of demographic depression, are Osijek-Baranja, Sisak-Moslavina, Zagreb, and Požega-Slavonia. This trend highlights that the counties of Central

and Eastern (Pannonian) Croatia are leading in the decline of demographic vitality.[3]

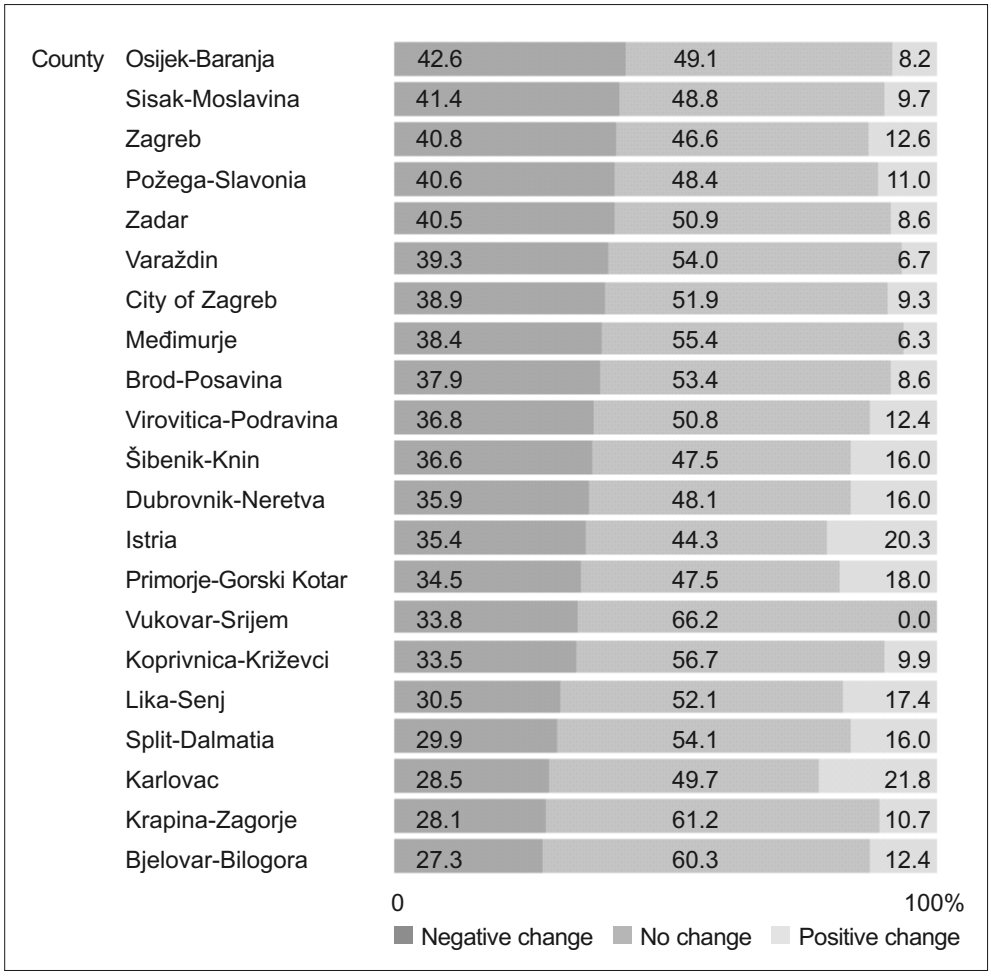


FIGURE 4
Share of settlements based on the change in the I_{DD} by counties (2011–2021)

The issues of depopulation and emigration in this area are well recognised in both public and scientific discourse. The primary cause of the sharp decline in vitality for the Požega-Slavonia, Sisak-Moslavina, Osijek-Baranja, and Vukovar-Srijem counties is emigration, evidenced by a negative migration balance. According to Eurostat data, from 2015 to 2020, the Vukovar-Srijem County recorded the highest population emigration rate in the EU, at -2.5% per year. The Požega-Slavonia County follows with -2.3%, Sisak-Moslavina at -2.1%, and the Osijek-Baranja County at -1.7% (Eurostat, 2023). Figure 5 shows the migration balance for settlements in these four counties, with almost 89% of settlements experiencing a negative migration balance between 2011 and 2021. The results indicate that the Sisak-Moslavina, Požega-Slavonia, Osijek-Baranja, and

Vukovar-Srijem counties lead in terms of negative migration balance (Figure 5). Contributing factors to these outcomes may include natural population decline, failed economic activities, environmental degradation, inadequate rural settlement planning within counties, lower quality of life, outdated infrastructure, and for the Sisak-Moslavina County specifically, the earthquake that affected the area, accelerating emigration. In conclusion, the inter-census period saw an intensification of demographic depression, not only in areas with a history of high emigration but also in counties previously less impacted by intensive emigration.

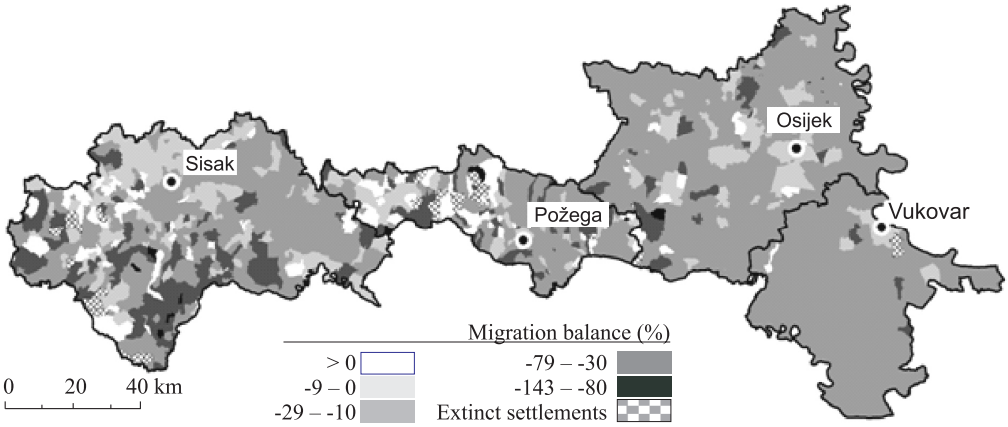


FIGURE 5
Migration balance 2011–2021 by settlement for Sisak-Moslavina, Požega-Slavonia, Osijek-Baranja and Vukovar-Srijem counties

The decline in vitality in the settlements of Zagreb County results from multiple factors. Although Zagreb County recorded the highest positive migration balance in 2021, it has also been impacted by negative demographic trends. As in other parts of Croatia, the population in Zagreb County is ageing, particularly in peripheral areas. Migration trends have also contributed to the decline in vitality, with young people who are unable to find work locally either migrating abroad or moving to the capital, leading to depopulation in smaller settlements. The population that immigrates to the county in search of better living conditions or employment often delays childbearing due to economic and social factors. Furthermore, in areas near large cities, shifts in family structures and social norms, such as later marriages and delayed childbearing, are more pronounced, and Zagreb County is no exception. Physical geography also plays a role, as it is a geographically diverse county with numerous settlements. Although the positive influence of Zagreb is apparent in areas immediately surrounding it, the outer edges of the county are experiencing negative demographic shifts, as seen in most peripheral areas in Croatian counties.

CONCLUSION

This paper analyses 11 criteria used to derive the index of demographic depression (I_{DD}) and compares its values between 2011 and 2021. The results show that in 2011, according to all 11 criteria, 44 settlements fell into the category of *extremely depressed* areas, with Bijeli Klanac, Valići, Zut, and Bucalovići being the most demographically depressed. There were 12 settlements in the extremely vital category, though none displayed all 11 criteria indicative of extreme vitality. The four most demographically vital settlements were Parag, Piškorovec, Krničari, and Dedin. In 2021, results indicate that 88 settlements are classified as extremely depressed. Five settlements fall within the extremely vital category; however, none meet all 11 criteria of extreme vitality. According to the I_{DD}, the four most demographically vital settlements in Croatia in 2021 are Piškorovec, Parag, Donje Vratno-dio, Dedin, and Veliko Polje.

According to the data for 2011 and 2021, the largest share of settlements falls within the *depressed area* category, while the smallest share is in the *extremely vital area* category. In terms of absolute changes in settlement numbers by category, the largest increase occurred in the *depressed area* category, and the largest decrease was in the category *on the edge of demographic depression*, as category (3) shifted into more *demographically depressed areas*. The categories of *vital* and *extremely vital* areas did not show an increase. Through the application of the I_{DD}, 53 settlements were identified as potential new 'dead settlements', based on two specific criteria.

Although the intensification of demographic depression is spatially present in almost all of Croatia, the areas that have experienced a marked negative change – specifically, an increase in I_{DD} at higher administrative levels – include the municipality of Gračac, Donji Lapac, and the town of Obrovac. However, the areas of Central and Eastern Slavonia experienced the most intense negative change.

The derived I_{DD} can be viewed as a tool for quantifying and mapping the extent of demographic ageing and for understanding and addressing the challenges associated with population ageing. It can be applied in the field of (a) regional planning to formulate targeted strategies that take into account the unique needs of older populations, ensuring sustainable development aligned with demographic changes; (b) optimisation of health functions and services – identifying regions characterised by demographic ageing enables better positioning and equipping of health institutions, which ultimately improves overall health outcomes; (c) optimisation of social welfare programmes – decision-makers can adjust and plan social welfare programmes based on the insights provided by I_{DD};

(d) workforce planning – businesses and industries face the challenge of adapting to an ageing yet increasingly active workforce. I_{DD} can serve as a tool for predicting changes in the labour market and adapting policies to promote workplace sustainability.

In future research, it is desirable to enhance the I_{DD} by modifying the weighting coefficient (influence) of the corrective factor, specifically the number of inhabitants, on the output result. This criterion is an important element of demographic resources and potential. In the existing methodological framework, all 11 criteria had the same weight coefficient. The disadvantage of such an approach is that in a settlement with a small number of inhabitants (e.g., 6), if a certain change occurs, such as the immigration of a few inhabitants or the birth of a few inhabitants, relative values of specific criteria (e.g., migration balance, % of young population) are generated, which classify that settlement in the extremely vital (%) category – an outcome that does not necessarily correspond to reality. This issue will be addressed in future research by modifying the weighting coefficients of all criteria, including the corrective criterion of demographic mass or standardised characteristics (z-values).

With the aim of thematically expanding the I_{DD}, the authors are considering generating an index of socio-demographic depression (I_{SDD}), which, in addition to demographic criteria, would include additional social and natural criteria to better identify demographically and functionally marginalised areas. The stated criteria would include, for example, the distance from primary healthcare centres, schools, universities, shops, pharmacies, post offices, key roads, etc.

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NOTES

[1] The average value of the I_{DD} of the Croatia was calculated as the mean value of the categories of all settlements (1-5). Extinct settlements were not excluded from the analysis. A value of category 0 was added. For example, that the Republic of Croatia consists of five settlements, two of which have a value of category 5 (extremely vital), one has a value of 4 (vital), one has a value of 1 (extremely depressed), and one is an extinct settlement (0), the average value of I_{DD} in this scenario would be 3.00 (edge of demographic depression).

[2] Potential new 'dead villages' in Croatia: Bandino Selo (City of Slunj), Barovka (Municipality of Krašić), Bojna (City of Glina), Iševnica (City of Delnice), Ponor Korenički (Municipality of Plitvička Jezera), Ponorac Perjasički (Municipality of Barilović), Razloški District (City of Delnice), Crljenci (Municipality of Brestovac), Kričke (City of Nov-

ska), Delači (Municipality of Brod Moravice), Koturić (City of Pakrac), Donja Stranica (Municipality of Ribnik), Kruškovac (City of Gospić), Kraljevo Selo (Municipality of Bosiljevo), Snos (City of Slunj), Gornji Dobretin (Municipality of Dvor), Srednji Poloj (Municipality of Barilović), Gornji Ložac (City of Delnice), Pribudić (Municipality of Gračac), Poljana (City of Vrbovsko), Kričke (City of Pakrac), Korita (City of Lipik), Drakulić Rijeka (Municipality of Plitvička Jezera), Štirkovac (Municipality of Barilović), Jovac (Municipality of Dvor), Mali Prolog (Municipality of Pojezerje), Burić Selo (Municipality of Krnjak), Golubići (City of Samobor), Grič (Municipality of Žumberak), Donja Visočka (City of Slunj), Dubrave (City of Slunj), Vodice (Municipality of Lanišce), Glavičani (Municipality of Dvor), Sertić Poljana (Municipality of Plitvička Jezera), Ćore (Municipality of Dvor), Krajna (Municipality of Čačinci), Laze Prnjavor (City of Požega), Kamenski Vučjak (Municipality of Brestovac), Mala Ciglena (City of Bjelovar), Mala Kosa (Municipality of Barilović), Pernat (City of Cres), Sveti Petar (City of Cres), Prvinci (Municipality of Krašić), Pušina (Municipality of Čačinci), Radočaj Brodski (City of Delnice), Rapain Klanac (Municipality of Brinje), Selci (Municipality of Bizovac), Šljivovac (Municipality of Gvozd), Tihočaj (City of Jastrebarsko), Veliki Obljaj (City of Glina), Vukoševac (Municipality of Sunja).

[3] Croatian statistical areas determined by the State Statistical Office of Croatia in cooperation with Eurostat.

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Promjena vrijednosti indeksa demografske depresije po naseljima Hrvatske u međupopisnom razdoblju 2011.–2021.

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Dugogodišnje smanjivanje ukupnoga broja stanovnika, starenje stanovništva te društvena marginalizacija ruralnih prostora uzrokovali su negativne demografske trendove u gotovo cijeloj Hrvatskoj. Pojmovi izumiranja, demografske depresije i demografske ugroženosti najčešće se povezuju s pojavom demografskoga smanjivanja i ekonomskoga propadanja naselja. U ovom radu prikazani su rezultati usporedbe indeksa demografske depresije (I_{DD}) po naseljima Hrvatske 2011. i 2021. godine. I_{DD} je izveden na temelju 11 demografskih kriterija definiranih u Mrđen i Marić

(2018). Prosječna vrijednost IDD-a svih naselja u Hrvatskoj za 2011. godinu iznosi 2,22 (depresivan/na rubu demografske depresije), dok za 2021. iznosi 2,20. Najveći udio naselja prema podacima za 2011. i 2021. godinu ulazi u kategoriju depresivnoga prostora. Očekivano, najmanji udio naselja ulazi u kategoriju izrazito vitalnoga prostora. Ako se promatra apsolutna promjena broja naselja po razredima I_{DD}-a zabilježen je najveći porast kategorije depresivnoga prostora, a najveće smanjenje je zabilježeno za kategoriju na rubu demografske depresije. Kategorije vitalnoga i izrazito vitalnoga prostora nisu zabilježile povećanje. I_{DD} može biti primijenjen u analizi, odnosno prepoznavanju demografskih resursa nekoga prostora s ciljem smanjenja nejednakosti u društveno-gospodarskom razvoju, odnosno prostorne neuravnoteženosti.

Ključne riječi: demografska depresija, depopulacija, starenje, Hrvatska