

DEMOGRAPHIC VULNERABILITY IN ROMANIA BETWEEN 1992-2025: A MULTIDIMENSIONAL ANALYSIS BASED ON A COMPOSITE INDEX

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Abstract: This study analyses the demographic vulnerability of Romania's 41 counties and Bucharest Municipality over the period 1992-2025, using a panel dataset of 1,428 county-year observations. Vulnerability is treated as a multidimensional

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phenomenon resulting from the interaction of population ageing, the weakening of reproductive potential, natural population imbalance, and territorial mobility. Based on time series covering population by domicile, age and sex structure, births, deaths, and migration flows, a Demographic Vulnerability Index (DVI) comprising four dimensions and eight indicators is constructed. The indicators are winsorized at the 1st and 99th percentiles, min-max normalized across the entire panel, and aggregated using equal weights, while the results are tested through alternative normalization procedures and external validation against population dynamics. At the national level, the population by domicile declines from 23.13 million in 1992 to 21.67 million in 2025 (-6.29%); the share of persons aged 65 and over increases from 11.0% to 18.7%; and the ageing index rises from 48.7 to 135.4 older persons per 100 children. The 15-24/55-64 generational replacement ratio falls from 156.4 to 78.7, while the rate of natural increase deteriorates from -0.15‰ to -4.34‰. In 2025, the highest DVI values are recorded in Brăila, Hunedoara, Caraş-Severin, Teleorman, and Tulcea, whereas the lowest are found in Ilfov, Suceava, Iaşi, and Bistriţa-Năsăud. The mean DVI for 1992-2025 is strongly associated with cumulative population loss (Spearman's $\rho = -0.884$; $p < 0.001$), and the rankings remain stable under alternative specifications. The results reveal pronounced territorial polarization and demonstrate that demographic vulnerability cannot be reduced to depopulation alone, thereby calling for differentiated public-policy responses.

Key words: demographic vulnerability; depopulation; ageing; fertility; migration; composite index; counties; Romania

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INTRODUCTION

Demographic transformations represent one of the most persistent sources of pressure on European territorial development. Population decline, ageing, the contraction of younger cohorts, and population redistribution through migration do not occur uniformly; instead, they generate differentiated spatial configurations in which numerical decline may coexist with a relatively favourable age structure, while positive population dynamics may conceal processes of ageing or a weakening reproductive base. From this perspective, demographic vulnerability should be understood as a reduced capacity of a territory to reproduce its population, maintain intergenerational balance, and offset natural population losses through mobility.

Romania represents a relevant case for such an analysis. Since 1990, economic transition, industrial restructuring, declining fertility, the liberalization of international mobility, and the intensification of international migration have profoundly reshaped the geography of population. These processes have had uneven territorial effects: rural counties in the south and east, former industrial areas, and certain peripheral territories have accumulated demographic losses, whereas counties with university centres and strong economic poles, as well as Bucharest's suburban area, have benefited to a greater extent from internal population redistribution. Romanian scholarship confirms the persistence of regional and county-level demographic disparities (Benedek & Török, 2014; Muntele, Istrate, Horea-Şerban, & Bănică, 2021; Mitrică, et al., 2022).

The main objective of the study is to provide a comparative and longitudinal assessment of demographic vulnerability across all Romanian counties and Bucharest Municipality over the period 1992-2025. To this end, the study aims to: (1) describe the main structural transformations of the population; (2) construct a composite index synthesizing four dimensions of vulnerability; (3) identify counties characterized by persistent, emerging, or low vulnerability; (4) assess regional differences; and (5) test the robustness and validity of the resulting construct.

The contribution of the study is twofold. Empirically, it uses a long annual series covering 1992-2025 at a stable and comparable territorial level. Methodologically, the proposed index does not directly include cumulative population loss, which is retained as an external validation variable. This avoids a form of circularity in which depopulation would simultaneously constitute a component of the index and an outcome used to demonstrate its validity. Vulnerability is therefore measured through the structural and demographic mechanisms that may generate or reinforce decline.

LITERATURE REVIEW

Demographic vulnerability: from numerical decline to multidimensional processes

Recent literature on depopulation shows that numerical population decline is the aggregate outcome of different combinations of fertility, mortality, and migration. For Italy it was demonstrated (Reynaud, Miccoli, Benassi, Naccarato, & Salvati, 2020) the mosaic-like and highly contextual character of local depopulation, while others (Newsham & Rowe, 2023) identify distinct trajectories of decline across European rural and urban areas. A subsequent analysis by the same authors shows that the relative roles of natural population change and migration vary considerably among European regions (Newsham & Rowe, 2025). These contributions support treating vulnerability as a process rather than merely as a demographic state.

Spatial interdependence is also as depopulation has regional determinants and neighbourhood important effects (Alamá-Sabater, Budí, Roig-Tierno, & García-Álvarez-Coque, 2021), while other authors (Segers, Devisch, Herssens, & Vanrie, 2020) argue that demographic shrinkage should be integrated into spatial-planning practice even in regions that are growing in aggregate terms. Drawing on the Dutch experience (Beunen, Meijer, & de Vries, 2020) it was emphasize the need for planning strategies adapted to declining territories rather than assuming that all areas can return to growth. For the present analysis, these arguments justify comparing counties both cross-sectionally and longitudinally.

Ageing, fertility, and generational replacement

Population ageing results from the interaction of increased longevity, low fertility, and age-selective mobility (Jakovljevic, et al., 2018), highlighting the scale of the process in the European Union and its eastern and southern neighbourhood, while other authors (Lamnisos, Giannakou, & Jakovljevic, 2021) discuss its implications for the sustainability of health and social systems in Greece and Cyprus. At the regional scale (Krisjane, Berzins, Krumins, Apsite-Berina, & Balode, 2023) there was demonstrate that ageing and decline are unevenly distributed, while Nicolini & Roig (2024) confirm the relationship between age structure and growth trajectories in European regions. Majdzińska (2024) shows that depopulation and ageing intensified across numerous European regions during the 2010s, albeit with differing territorial intensities.

Fertility constitutes a second essential component. Some perspectives (Balbo, Billari, & Mills, 2013) show that fertility in advanced societies is simultaneously influenced by individual, couple-level, institutional, and macroeconomic factors. At the spatial level (Salvati, Benassi, Miccoli, Rabiei-Dastjerdi, & Matthews, 2020) it is highlighted the regional and local heterogeneity in fertility and birth rates within a low-fertility context. Consequently, the crude birth rate alone is insufficient: the size of the female population aged 15-49 and the ratio between generations entering and leaving working ages provide additional information on demographic reproductive capacity.

Mapping ageing indices can directly support the identification of high-risk territories. It was demonstrated the usefulness of combining age-related indicators with spatial classification and clustering tools (Sánchez-Martín, Gurriá-Gascón, & Rengifo-Gallego, 2025). Following the same logic, the present study includes an ageing index and a generational replacement ratio, while avoiding the simultaneous inclusion of an excessive number of nearly collinear indicators.

Romania: territorial disparities, rurality, migration, and urban shrinkage

For Romania, the literature highlights persistent territorial differences. Early geodemographic research on Romanian rural space emphasized the demographic weight of rural areas and the importance of population structure and dynamics for territorial stability (Staşac, Albu, & Stupariu, 2010).

Benedek & Török (2014) analysed county-level demographic disparities, while other authors (Dumitraşcu, Trică, & Caragea, 2018) synthesized the main patterns and trends of Romania's population. At the rural level, Hărăguş & Földes (2020) describe the unfavourable demographic profile of many rural areas, whereas different perspectives (Muntele, Istrate, Horea-Şerban, & Bănică, 2021) advanced the concept of rural demographic resilience and demonstrate pronounced long-term territorial differences.

Regional and subregional analyses confirm the heterogeneous nature of these processes. Erchedi (2021) identifies specific demographic risks in Moţilor Land, while other authors (Muntele, Istrate, Athes, & Bănică, 2023) describe, for the Romanian Carpathians, the relationship between population dynamics, accessibility, urbanity, and rurality. For Sibiu County it was shown how natural and migration balances combine to shape territorial dynamics (Rusu, Moldovan, Man, Bîrsănuş, & Ursu, 2024). These findings support the need for a nationwide approach that enables comparisons across all counties.

Migration is a central mechanism of demographic vulnerability in Romania. Stupariu, Herman & Grama (2018), analysed Romanian migration flows to Italy over 2008-2016 using Eurostat data, highlighted the structural differentiation of migration and the value of destination-specific quantitative analysis. More broadly, other authors (Mitrică, et al., 2022) linked out-migration to social and technological marginalization and highlight regional disparities. At the same time, differences between the administratively registered population and the population actually resident in a territory may be amplified by international mobility, requiring caution when interpreting series based on domicile.

Another strand of the literature addresses urban demographic change and shrinking cities. At the city scale, Stupariu (2014) examined population, urban functions, quality of life, and development trajectories within a comprehensive urban-geographical analysis of Oradea, illustrating how demographic processes are embedded in wider urban transformations.

Few authors compared the urban shrinkage in Romania and the Netherlands (Țăruş, Dezsi, Crăciun, Pop, & Tudorache, 2022), further discussing the possible policy frameworks. In the same time, other authors (Vîlcea, Popescu, & Clincea, 2024) showed that population decline in small towns does not automatically equate to economic and social decline. Săgeată, Dumitrică, & Baroiu, (2025) examined the relationship between depopulation and the development of peri-urban green areas around large cities, highlighting the indirect spatial effects of demographic restructuring.

Regarding biological and family-related components, previous research (Muntele, Istrate, Bănică, & Horea-Şerban, 2020) analysed the territorial differences in life expectancy, while others (Țăruş, Dezsi, & Pop, 2021) projected the ageing of the urban population in Transylvania. Finally, Cîmpoeru & Pisićă (2023) investigated the economic determinants and spatial distribution of birth rates. These transformations were placed within the broader framework of socioeconomic development (Iancu, et al., 2022).

Family behaviour also exhibits pronounced spatial and structural differentiation: Stupariu, Staşac, & Linc (2024) analysed divorce dynamics in Romania over 1992-2023 by residence, region, and socio-demographic characteristics, while other authors (Staşac, et al., 2025) highlighted the recent changes in demographic behaviour and in the marriage-to-divorce ratio. Using regional panel analysis, Jemna & David (2021) emphasize the role of factors driving ageing. Taken together, these studies indicate the need for a synthetic instrument capable of distinguishing structural vulnerability from simple numerical population change.

Composite indices, normalization, and robustness

Constructing a composite index involves normative and technical decisions concerning indicator selection, normalization, orientation, weighting, and aggregation. Mazziotta & Pareto (2013) showed that there is no universally optimal method and that the chosen solution should be adapted to the nature of the phenomenon under analysis. In the same time there was systematized (Greco, Ishizaka, Tasiou, & Torrìsi, 2019) the main methodological issues associated with composite indices and recommend explicitly assessing robustness to alternative weighting and normalization procedures.

The index used here is designed with a limited number of indicators organized into conceptually distinct dimensions, with equal weights and a common normalization framework for all years. This choice facilitates temporal interpretation and reduces the risk that changes in rankings are driven by arbitrary shifts in annual distributions. In addition, cumulative population loss is not included in the index but is instead used for its external validation.

MATERIALS AND METHODS

Database and unit of analysis

The analysis covers annual series for the period 1992-2025 at the level of Romania's 41 counties and Bucharest Municipality. The elementary unit is the county-year observation, yielding $42 \times 34 = 1,428$ observations. The database includes total population, five-year age-group structure, sex structure, live births, deaths, deaths under one year of age, women of reproductive age, domicile registrations and departures, residence registrations and departures, immigration and emigration involving a change of domicile, marriages, divorces, area, and the urban-rural distribution of the population. County area is expressed in hectares. Population values are treated as population by domicile as of 1 July. This concept is applied consistently throughout the entire period in order to avoid mixing it with resident population.

Derived indicators

Additional descriptive indicators - the share of the population aged 65+, the share aged 80+, old-age demographic dependency, the crude birth rate, the crude death rate, population density, and the urban population share - are used for interpretation but are not included in the index when they would duplicate information already captured by a component indicator (Table 1).

Table 1. Indicators included in the Demographic Vulnerability Index
(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Dimension	Indicator	Formula / definition	Direction of vulnerability
Ageing	Ageing index (AI)	$P_{65+} / P_{0-14} \times 100$	higher = more vulnerable
Ageing	Generational replacement ratio (GRR)	$P_{15-24} / P_{55-64} \times 100$	lower = more vulnerable
Reproduction	General fertility rate (GFR)	$\text{Live births} / F_{15-49} \times 1,000$	lower = more vulnerable
Reproduction	Share of women aged 15-49 (SW15-49)	$F_{15-49} / F_{\text{total}} \times 100$	lower = more vulnerable
Natural balance	Rate of natural increase (RNI)	$(\text{Live births} - \text{Deaths}) / P \times 1,000$	lower = more vulnerable
Natural balance	Infant mortality rate (IMR)	$\text{Deaths} < 1 \text{ year} / \text{Live births} \times 1,000$	higher = more vulnerable
Migration	Net domicile migration rate (NDMR)	$(\text{Registrations} - \text{Departures}) / P \times 1,000$	lower = more vulnerable
Migration	Net international migration rate (NIMR)	$(\text{Immigrants} - \text{Emigrants}) / P \times 1,000$	lower = more vulnerable

Construction of the Demographic Vulnerability Index (DVI)

To ensure temporal comparability, normalization is performed across the entire 1992-2025 panel rather than separately for each year. Before normalization, each indicator is winsorized at the 1st and 99th percentiles to limit the influence of extreme values without removing observations.

For risk indicators: $V = (x^* - \min x^*) / (\max x^* - \min x^*)$

For protective indicators: $V = (\max x^* - x^*) / (\max x^* - \min x^*)$

where x^* denotes the winsorized value. Scores range from 0 to 1 and are multiplied by 100. The eight indicators are grouped into four dimensions: (D1) ageing and generational imbalance; (D2) reproductive potential; (D3) natural population change and survival; and (D4) mobility and demographic attractiveness. Each dimension is calculated as the mean of its two indicators, while the final index is the arithmetic mean of the four dimensions.

$$DVI = (D1 + D2 + D3 + D4) / 4$$

The DVI theoretically ranges from 0 to 100, with higher values indicating greater demographic vulnerability. Equal weights were selected for transparency and to avoid assigning empirically unstable levels of importance to a phenomenon composed of conceptually distinct dimensions. Because each dimension contains two indicators, each indicator implicitly contributes 12.5% to the final index. Population loss over 1992-2025 is not included in the DVI. It is treated as an external outcome used to assess construct validity. Likewise, the balance of residence changes is analysed descriptively but is not combined with the domicile migration balance because the two flows have different administrative meanings.

Classification, validation, and robustness tests

For 1992 and 2025, counties are grouped into five relative classes based on quintiles of the DVI distribution: very low, low, medium, high, and very high. These classes are relative to the distribution of the 42 territorial units and should not be interpreted as absolute risk thresholds.

External validity is assessed through the association between the mean DVI over 1992-2025 and cumulative population change between 1992 and 2025. Both Spearman and Pearson correlation coefficients are calculated. Robustness is evaluated using two tests: (a) replacing min-max normalization with z-score standardization followed by transformation using the normal cumulative distribution function; and (b) recalculating the index without the international migration component. The stability of the 2025 rankings is assessed using Spearman's coefficient.

RESULTS

National demographic trajectory

Between 1992 and 2025, Romania's population by domicile decreased from 23,126,797 to 21,671,469 persons, representing a decline of 1.455 million people, or -6.29%. Numerical decline, however, is only one dimension of the transformation. The structural change is more profound: the share of the population aged 65 and over increased from 11.01% to 18.70%, while the ageing index rose from 48.7 older persons per 100 children in 1992 to 135.4 in 2025. This reversal in the ratio between older people and children indicates a shift from a population structure with a relatively broad base to one in which older generations numerically exceed the population aged 0-14.

The 15-24/55-64 generational replacement ratio provides a complementary perspective. In 1992, there were approximately 156 persons aged 15-24 for every 100 persons aged 55-64; by 2025, the ratio had fallen to 78.7. Structurally, the cohort approaching entry into the main working-age segment is now considerably smaller than the cohort approaching exit from it. The share of women

aged 15-49 in the total female population declined to 44.0% in 2025, reinforcing negative demographic momentum (Table 2).

Table 2. Transformation of Romania's demographic
(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Year	Population	65+ (%)	Ageing index	GRR 15-24/55-64	Women aged 15-49 (%)
1992	23,126,797	11.01	48.74	156.43	48.11
1993	23,098,108	11.29	51.39	149.56	48.66
1994	23,078,952	11.57	54.18	147.45	49.16
1995	23,033,618	11.86	57.22	146.85	49.73
1996	22,962,740	12.10	60.00	150.33	50.23
1997	22,903,955	12.40	63.03	152.75	50.56
1998	22,864,721	12.65	65.31	154.89	50.73
1999	22,825,196	12.87	67.70	155.57	50.69
2000	22,809,610	13.13	70.98	157.71	50.71
2001	22,791,655	13.44	74.48	159.00	50.70
2002	22,748,121	13.68	78.73	160.98	50.97
2003	22,702,149	13.92	83.04	162.21	51.12
2004	22,656,570	14.15	87.24	158.30	51.26
2005	22,621,457	14.37	91.55	153.91	51.16
2006	22,594,368	14.37	92.42	144.16	50.78
2007	22,562,913	14.46	93.93	137.03	50.42
2008	22,542,169	14.48	94.43	129.71	50.01
2009	22,520,477	14.54	95.18	123.65	49.69
2010	22,492,083	14.53	95.07	113.49	49.40
2011	22,441,740	14.58	95.73	105.81	49.18
2012	22,401,865	14.67	96.71	97.69	49.06
2013	22,359,849	14.80	98.40	90.96	49.03
2014	22,299,730	15.16	101.88	86.82	49.02
2015	22,286,392	15.47	103.81	83.68	48.98
2016	22,247,551	15.80	106.50	83.26	48.98
2017	22,219,173	16.09	108.41	82.97	48.80
2018	22,215,742	16.40	110.60	84.22	47.52
2019	22,205,476	16.66	112.46	85.15	46.75
2020	22,192,107	17.13	115.89	88.22	46.11
2021	22,080,151	17.33	117.38	91.55	45.72
2022	21,984,277	17.55	119.33	93.42	45.38
2023	21,892,048	17.96	124.06	85.74	45.00
2024	21,801,351	18.36	129.07	81.91	44.54
2025	21,671,469	18.70	135.36	78.75	44.04

Births, fertility, mortality, and natural population change

Natural population dynamics deteriorated substantially. The general fertility rate, calculated as live births per 1,000 women aged 15-49, declined from 46.13 in 1992 to 29.80 in 2025. The crude birth rate fell from 11.26‰ to 6.72‰. At the same time, the rate of natural increase, already slightly negative in 1992 (-0.15‰), reached -4.34‰ in 2025. The year 2021 stands out for an exceptional natural deficit of -6.04‰, associated with increased mortality during the pandemic period (Table 3).

Table 3. Natural population dynamics

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Year	GFR (% women aged 15-49)	Birth rate (‰)	Death rate (‰)	Natural increase (‰)	Infant mortality (‰)
1992	46.13	11.26	11.41	-0.15	23.35
1993	43.81	10.82	11.40	-0.58	23.29
1994	42.81	10.69	11.53	-0.84	23.89
1995	40.64	10.27	11.79	-1.52	21.24
1996	39.43	10.07	12.46	-2.39	22.30
1997	40.18	10.34	12.20	-1.85	21.99
1998	40.15	10.38	11.77	-1.39	20.51
1999	39.78	10.28	11.62	-1.34	18.58
2000	39.76	10.28	11.22	-0.93	18.63
2001	37.38	9.67	11.39	-1.72	18.41
2002	35.57	9.25	11.85	-2.60	17.33
2003	35.85	9.36	11.74	-2.38	16.69
2004	36.44	9.55	11.43	-1.88	16.84
2005	37.37	9.77	11.59	-1.82	14.98
2006	37.42	9.71	11.42	-1.71	13.91
2007	36.92	9.52	11.17	-1.65	11.99
2008	38.49	9.84	11.23	-1.39	10.97
2009	38.85	9.87	11.42	-1.55	10.12
2010	37.32	9.43	11.55	-2.11	9.79
2011	34.73	8.74	11.20	-2.46	9.43
2012	35.75	8.98	11.41	-2.43	9.01
2013	38.30	9.61	11.20	-1.59	7.82
2014	36.19	9.08	11.46	-2.38	8.09
2015	36.90	9.25	11.80	-2.55	7.32
2016	37.59	9.42	11.64	-2.21	6.68
2017	38.73	9.67	11.83	-2.16	6.37
2018	39.73	9.66	11.95	-2.29	5.73
2019	40.58	9.70	11.77	-2.07	5.36
2020	40.36	9.52	13.52	-4.00	5.24
2021	39.36	9.21	15.25	-6.04	5.00
2022	36.87	8.57	12.46	-3.90	5.43
2023	32.51	7.49	11.17	-3.68	5.52
2024	31.63	7.21	11.27	-4.06	6.09
2025	29.80	6.72	11.06	-4.34	5.50

The evolution of infant mortality represents the major favourable exception: the rate fell from 23.35 deaths under one year of age per 1,000 live births in 1992 to 5.50 in 2025. The decline in infant mortality indicates substantial improvements in early-life survival, but this favourable trend does not offset the contraction of reproductive cohorts and the decline in births.

Territorial differentiation of depopulation

The national change of -6.29% conceals very large territorial contrasts. Teleorman lost 31.86% of its population by domicile between 1992 and 2025, followed by Olt (-23.35%), Hunedoara (-22.30%), Caraş-Severin (-20.67%), and Brăila (-20.67%). Mehedinţi, Tulcea, Buzău, Giurgiu, and Călăraşi also belong to this group. In varying proportions, these counties combine ageing, natural population deficit, and a limited capacity to attract and retain population. At the opposite end, Ilfov recorded an increase of 94.67%, primarily reflecting metropolitan suburbanization and transfers of domicile from Bucharest's urban core and from other territories.

Population increases are also observed in Iași (+19.77%), Timiș (+7.56%), Suceava (+6.81%), Vaslui (+3.65%), Brașov (+2.32%), Sibiu (+2.10%), and Cluj (+1.58%). These values should not be confused with resident-population dynamics; they reflect the administrative concept of population by domicile (Table 4).

Table 4. Natural population dynamics

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Largest declines	1992-2025 (%)	Largest increases / smallest declines	1992-2025 (%)
Teleorman	-31.86	Ilfov	+94.67
Olt	-23.35	Iași	+19.77
Hunedoara	-22.30	Timiș	+7.56
Caraș-Severin	-20.67	Suceava	+6.81
Brăila	-20.67	Vaslui	+3.65
Mehedinți	-19.74	Brașov	+2.32
Tulcea	-19.46	Sibiu	+2.10
Buzău	-18.47	Cluj	+1.58
Giurgiu	-17.94	Constanța	+0.17
Călărași	-15.27	Bistrița-Năsăud	-2.69

Demographic Vulnerability Index in 1992 and 2025

In 2025, the highest vulnerability is concentrated in Brăila (84.87), Hunedoara (84.57), Caraș-Severin (82.98), Teleorman (82.32), and Tulcea (81.40). The profiles of these counties are not identical. Brăila combines an almost maximum ageing score with very high reproductive vulnerability and unfavourable migration balances. Hunedoara strongly reflects the legacy of restructuring in a formerly industrial county, with advanced ageing and a natural population deficit. Teleorman stands out with a population share aged 65+ of approximately 24.1%, an ageing index of 205.2, and a rate of natural increase of -11.37‰. Although Vâlcea ranks sixth, it has an ageing index of 223.6, among the most unfavourable structural values.

Ilfov represents the principal favourable outlier, with an DVI of 39.78. The county has a 65+ population share of 13.1%, an ageing index of 80.9, and, in 2025, an internal net domicile migration rate of approximately +27.7‰. Suceava and Iași also record relatively low scores, supported by younger age structures and more favourable replacement ratios. However, Iași's score is affected by the international migration component involving a change of domicile, demonstrating the value of interpreting the index by dimension rather than relying solely on the final score (Figures 1-2, Table 5).

Table 5. DVI in 1992 and 2025

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

County	DVI 1992	Rank 1992	Class 1992	DVI 2025	Rank 2025	Class 2025	Δ DVI
Brăila	53.33	10	High	84.87	1	Very high	+31.54
Hunedoara	46.08	24	Medium	84.57	2	Very high	+38.48
Caraș-Severin	57.48	3	Very high	82.98	3	Very high	+25.50
Teleorman	67.93	1	Very high	82.32	4	Very high	+14.39
Tulcea	46.12	23	Medium	81.40	5	Very	+35.28

						high	
Vâlcea	46.02	25	Medium	81.12	6	Very high	+35.10
Olt	51.06	13	High	79.25	7	Very high	+28.19
Mehedinţi	52.67	11	High	79.07	8	Very high	+26.40
Buzău	50.70	15	High	77.99	9	Very high	+27.30
Prahova	50.22	18	Medium	77.50	10	High	+27.27
Argeş	41.42	33	Low	76.95	11	High	+35.53
Galaţi	39.59	38	Very low	75.42	12	High	+35.82
Neamţ	41.47	32	Low	75.01	13	High	+33.54
Gorj	38.53	40	Very low	74.73	14	High	+36.20
Alba	48.87	20	Medium	74.36	15	High	+25.48
Bucharest Municipality	51.04	14	High	74.08	16	High	+23.03
Dolj	54.96	7	Very high	73.68	17	High	+18.72
Vrancea	45.01	27	Low	71.96	18	Medium	+26.95
Bacău	38.79	39	Very low	71.75	19	Medium	+32.96
Arad	57.05	4	Very high	70.53	20	Medium	+13.48
Constanţa	42.78	30	Low	70.39	21	Medium	+27.61
Călăraşi	55.65	6	Very high	70.19	22	Medium	+14.54
Dâmboviţa	47.49	22	Medium	70.18	23	Medium	+22.69
Ialomiţa	53.73	8	Very high	70.06	24	Medium	+16.33
Giurgiu	62.74	2	Very high	69.36	25	Medium	+6.62
Maramureş	37.25	42	Very low	68.14	26	Low	+30.88
Botoşani	50.05	19	Medium	68.05	27	Low	+18.00
Satu Mare	45.80	26	Low	68.02	28	Low	+22.22
Covasna	43.21	28	Low	67.15	29	Low	+23.94
Mureş	47.79	21	Medium	66.93	30	Low	+19.15
Vaslui	42.87	29	Low	66.71	31	Low	+23.85
Timiş	50.26	17	High	65.05	32	Low	+14.79
Sibiu	40.56	36	Very low	64.84	33	Low	+24.27
Harghita	41.48	31	Low	64.24	34	Very low	+22.75
Sălaj	51.45	12	High	64.22	35	Very low	+12.77
Cluj	50.62	16	High	64.07	36	Very low	+13.46
Braşov	41.36	34	Very low	63.93	37	Very low	+22.57
Bihor	53.69	9	Very high	63.26	38	Very low	+9.57
Bistriţa-Năsăud	37.58	41	Very low	58.48	39	Very low	+20.90
Iaşi	40.69	35	Very low	57.32	40	Very low	+16.64
Suceava	39.74	37	Very low	55.26	41	Very low	+15.53
Ilfov	57.01	5	Very high	39.78	42	Very low	-17.24

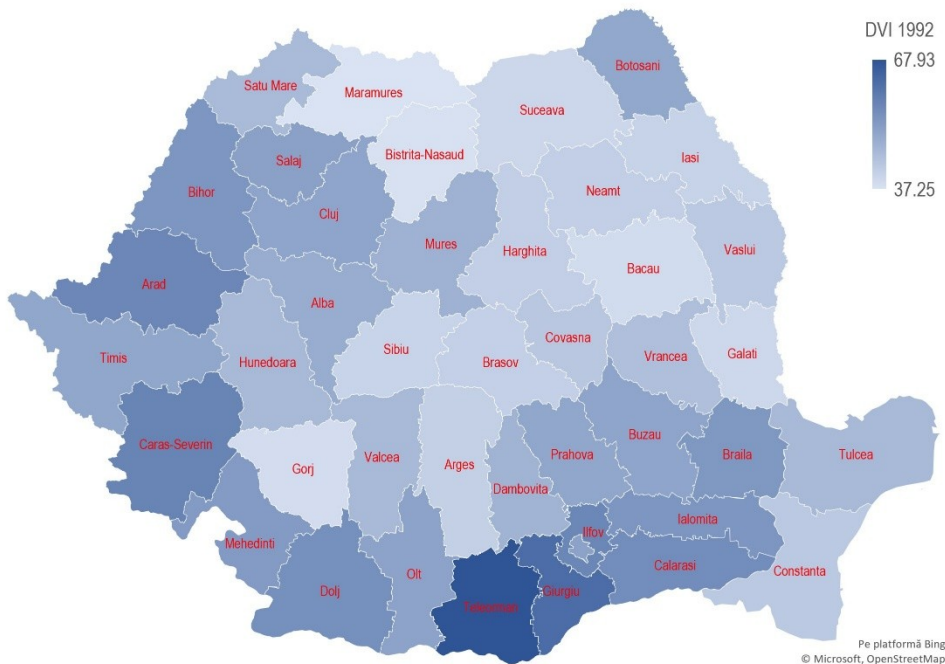


Figure 1. Distribution of the DVI at county level, 1992
(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

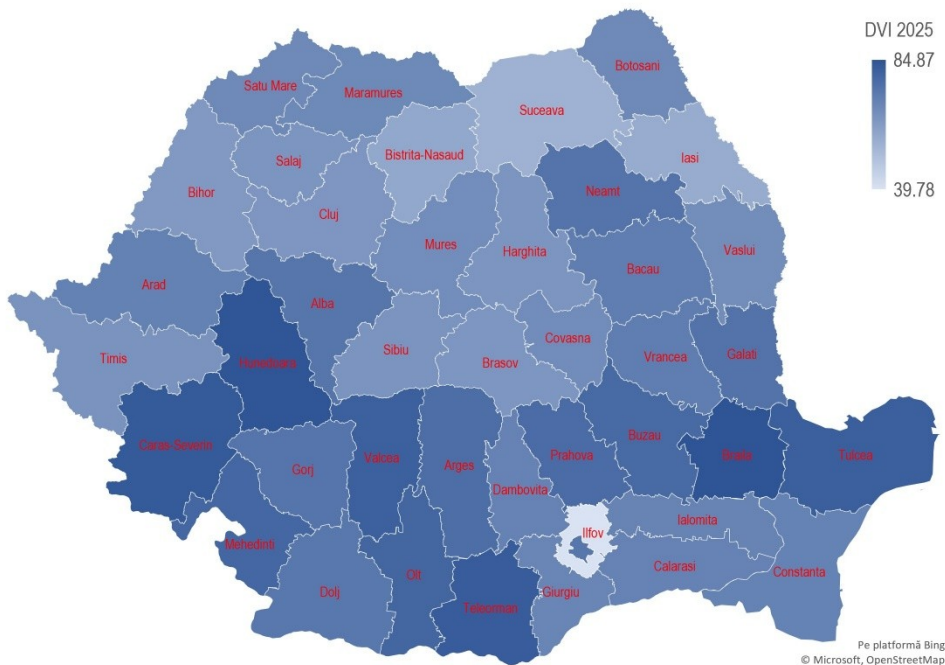


Figure 2. Distribution of the DVI at county level, 2025
(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Regional configuration

A comparative analysis of mean Demographic Vulnerability Index values across development regions highlights both the generalized increase in vulnerability between 1992 and 2025 and an important change in the territorial hierarchy. In 1992, the highest mean DVI values were recorded in South-Muntenia (54.17) and Bucharest-Ilfov (54.03), followed by the West region (52.72). At the opposite end were North-East (42.27) and Centre (43.88), regions characterized at the beginning of the period by comparatively more favourable demographic structures (Table 6).

Table 6. Unweighted mean* DVI by development region, 1992 and 2025

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

NUTS 2 region	Mean DVI 1992*	Mean DVI 2025*	Δ DVI 1992-2025
North-East	42.27	65.69	+23.42
South-East	46.26	77.00	+30.74
South-Muntenia	54.17	73.79	+19.62
South-West Oltenia	48.65	77.57	+28.92
West	52.72	75.78	+23.06
North-West	46.07	64.37	+18.30
Centre	43.88	66.91	+23.03
Bucharest-Ilfov	54.03	56.93	+2.90

*Unweighted arithmetic mean of county scores; it does not represent an index recalculated for the regionally aggregated population

By 2025, the regional configuration had changed substantially. South-West Oltenia became the region with the highest mean demographic vulnerability (77.57), followed very closely by South-East (77.00) and West (75.78). South-Muntenia, which ranked first in 1992, reached 73.79. This shift does not indicate an improvement in South-Muntenia's demographic situation - its DVI increased by 19.62 points - but rather a more rapid deterioration of the demographic profile in other regions, particularly South-East and South-West Oltenia.

The most pronounced regional increase in vulnerability occurred in South-East, where the mean DVI rose from 46.26 to 77.00, an increase of 30.74 points. An almost equally unfavourable trajectory characterized South-West Oltenia, with an increase of 28.92 points. These two regions started from intermediate levels of vulnerability in 1992 but occupied the top two positions in the national regional hierarchy by 2025. The trend indicates an accumulation of demographic imbalances over more than three decades, resulting from the combined effects of population ageing, declining generational replacement potential, deterioration of the natural balance, and migration flows insufficient to compensate for losses.

Substantial increases in the DVI are also observed in North-East (+23.42 points), West (+23.06), and Centre (+23.03). The case of North-East is particularly relevant: although the region records one of the largest absolute deteriorations in the index, its 2025 value - 65.69 - remains among the lowest in Romania. This reflects the considerable structural advantage it held in 1992, when North-East had the lowest regional DVI (42.27). Therefore, its relatively favourable position in 2025 should not be interpreted as an absence of demographic deterioration, but rather as the partial persistence of an initial advantage.

North-West records the smallest increase in vulnerability among the seven regions outside Bucharest-Ilfov, from 46.07 to 64.37, or +18.30 points. Consequently, in 2025 it becomes the region with the second-lowest mean vulnerability after Bucharest-Ilfov. This trajectory suggests a relatively greater capacity to preserve demographic balances than in the southern and south-eastern regions,

although an increase of more than 18 points shows that North-West is by no means exempt from the broader deterioration process.

Bucharest-Ilfov displays a distinct pattern. The regional DVI increases only from 54.03 in 1992 to 56.93 in 2025, a rise of 2.90 points, far below the changes recorded in all other regions. Consequently, the region moves from one of the relatively most vulnerable positions in 1992 to the lowest regional DVI value in 2025. This result must nevertheless be interpreted with caution because the regional mean combines two markedly different demographic trajectories. In 2025, Bucharest Municipality records an DVI of 74.08, whereas Ilfov, at 39.78, has the lowest vulnerability among all territorial units analysed. Ilfov's favourable dynamics, driven to a large extent by metropolitan population redistribution, substantially reduce the region's unweighted mean and mask the significantly higher vulnerability of the capital-city core.

The period 1992-2025 therefore reveals a predominant convergence towards higher levels of vulnerability rather than a general improvement in demographic conditions. The difference between the maximum and minimum regional values was approximately 11.9 points in 1992, while contrasts are larger in 2025, particularly because of the atypical position of Bucharest-Ilfov. At the same time, a clear geographical reconfiguration occurs: South-East and South-West Oltenia become the principal regional centres of demographic vulnerability, whereas North-West, North-East, and especially Bucharest-Ilfov occupy relatively more favourable positions. Nevertheless, regional means should be interpreted alongside differences among their constituent counties, as they may conceal substantial intraregional contrasts, as clearly illustrated by Bucharest-Ilfov and the West region.

Persistence and change, 1992-2025

The mean DVI over the entire period indicates persistent vulnerability in Teleorman (75.03), Giurgiu (64.32), Caraş-Severin (63.95), Brăila (63.84), Olt (63.40), Buzău (63.00), Mehedinţi (62.35), Hunedoara (62.03), and Dolj (61.30). At the opposite end are Iaşi (38.22), Ilfov (41.34), Suceava (41.52), Vaslui (44.28), and Bistriţa-Năsăud (44.40). These averages indicate that current vulnerability has a cumulative and structural character in many counties.

Deterioration is particularly rapid in Hunedoara, Tulcea, Vâlcea, and Brăila. Ilfov constitutes the major exception: its DVI decreases by 17.24 points between 1992 and 2025 as the county becomes an area of metropolitan attraction. This trajectory confirms the role of selective internal mobility in reshaping demographic structure over a relatively short period (Table 7).

Table 7. Examples of DVI trajectories between 1992 and 2025

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

County	DVI 1992	DVI 2025	Δ DVI
Teleorman	67.93	82.32	+14.39
Caraş-Severin	57.48	82.98	+25.50
Brăila	53.33	84.87	+31.54
Olt	51.06	79.25	+28.19
Buzău	50.70	77.99	+27.30
Mehedinţi	52.67	79.07	+26.40
Hunedoara	46.08	84.57	+38.48
Vâlcea	46.02	81.12	+35.10
Tulcea	46.12	81.40	+35.28
Ilfov	57.01	39.78	-17.24
Iaşi	40.69	57.32	+16.64
Suceava	39.74	55.26	+15.53

Validity and robustness of the index

The relationship between the mean DVI for 1992-2025 and cumulative population change over 1992-2025 is strongly negative: Spearman's $\rho = -0.884$ ($p < 0.001$), while the Pearson coefficient is $r = -0.679$ ($p < 0.001$). Counties with higher average structural vulnerability tend to experience larger demographic losses. The difference between the Spearman and Pearson coefficients suggests that the relationship is very clear in ordinal terms but not perfectly linear, which is plausible for a phenomenon influenced by metropolitan effects, industrial legacies, and regional specificities. Robustness is very high. The specification using z-score standardization and CDF transformation preserves the county ordering almost entirely ($\rho = 0.966$), while excluding international migration produces an almost identical ranking ($\rho = 0.989$). The main conclusions therefore do not depend on a single normalization choice or on a migration component that may be more sensitive to administrative definitions (Table 8).

Table 8. Validation and robustness tests

(Source: author's calculations based on data obtained from the Romanian National Institute of Statistics (NIS), Tempo-Online database, 2026)

Test	Spearman coefficient	p	Interpretation
Mean DVI 1992-2025 vs. population change 1992-2025	-0.884	<0.001	strong external validity
DVI 2025 min-max vs. z-score/CDF specification	0.966	<0.001	highly stable ranking
Full DVI 2025 vs. DVI without international migration	0.989	<0.001	very low sensitivity

DISCUSSIONS

The results confirm that demographic vulnerability in Romania has a strongly polarized geography. The concentration of high values in the south and south-west, the south-east, and several former industrial counties is consistent with the literature on county-level demographic disparities and territorial resilience (Benedek & Török, 2014); (Muntele, Istrate, Horea-Şerban, & Bănică, 2021). In these areas, decline is not driven by a single factor: ageing reduces the reproductive base, negative natural change accelerates contraction, and mobility fails to compensate for losses. This combination is close to the mechanisms identified in other depopulating European regions (Reynaud, Miccoli, Benassi, Naccarato, & Salvati, 2020); (Newsham & Rowe, 2025).

Teleorman represents a case of persistent and mature vulnerability. The county already had a high DVI in 1992 and remains in the upper quintile in 2025. Hunedoara and Caraş-Severin illustrate a different trajectory, in which industrial restructuring, migration, and ageing have intensified vulnerability over time. This interpretation is consistent with research linking out-migration to marginalization and with the literature on shrinking cities and regions (Mitrică, et al., 2022); (Țăruş, Dezsi, & Pop, 2021).

North-East exhibits a more ambivalent profile. Iaşi and Suceava remain among the counties with relatively low vulnerability because of younger age structures and stronger generational replacement capacity. However, international migration may erode this structural advantage. This finding is important for policy interpretation: a young age structure does not guarantee resilience if the younger population is exposed to intense international mobility. Romanian research on rural demographic profiles and migration supports this distinction (Hărăguş & Földes, 2020); (Mitrică, et al., 2022).

Ilfov demonstrates that internal mobility can reverse a trajectory. The decline in the DVI from 57.01 to 39.78 is associated with suburbanization and the attraction of adults and families. At the

same time, Bucharest records a substantially higher score, showing that a metropolitan region may simultaneously contain an ageing core and a demographically dynamic periphery. This form of differentiation supports the conclusion of (Segers, Devisch, Herssens, & Vanrie, 2020) that demographic shrinkage can coexist with growth within the same functional region.

The decline in infant mortality is one of the major favourable transformations, but its effect on population size is outweighed by the contraction of births and the ageing of the reproductive base. The evolution of the general fertility rate and the declining share of women aged 15-49 show why policies focused exclusively on stimulating the number of births may have limited effectiveness: the structural effect of small cohorts reduces the potential number of births even if individual fertility were to increase. This interpretation is consistent with the broader literature on low fertility (Balbo, Billari, & Mills, 2013) and with spatial analyses of birth rates in Romania (Cimpoeru & Pisică, 2023). From a public-policy perspective, the results support place-based interventions. Counties with very high vulnerability require a combination of adapting services to ageing, improving medical and social accessibility, maintaining infrastructure in low-density areas, attracting and retaining the working-age population, and adapting labour markets to shrinking cohorts. For relatively young counties, priorities differ: retaining young people, improving access to housing, supporting family services, and reducing migration pressures. In metropolitan areas, the main challenge becomes the capacity of infrastructure and services to absorb population redistribution. This differentiated approach is consistent with (Stupariu, 2023), who argues that demographic policy in the European Union should address low fertility, population ageing, and migrant integration in a more integrated manner, while strengthening coordination between EU and national policy levels and widening civil-society participation.

The DVI is neither an index of economic development nor a quality-of-life ranking. An economically successful county may display demographic vulnerability through ageing or a natural population deficit, whereas a county facing economic difficulties may temporarily retain a younger age structure. This conceptual distinction is essential and is supported by studies showing that demographic shrinkage and socioeconomic decline are not perfectly equivalent (Vîlcea, Popescu, & Clincea, 2024).

Limitations

The first limitation concerns the population concept used. Population by domicile captures administrative registration rather than the actual location of individuals. In a country characterized by substantial temporary and circular international migration, the difference from the resident population may be considerable. Consequently, the results describe the vulnerability of the demographic system as registered by domicile and should not be interpreted as a direct estimate of the de facto population present in each territory.

The second limitation concerns migration. Domicile registrations/departures, temporary residence, and international migration involving a change of domicile are distinct administrative flows. The index uses the domicile migration balance and the international migration balance without adding them to residence changes. Nevertheless, these series do not fully capture circular mobility or persons who leave without formally changing their domicile.

The third limitation relates to fertility and mortality indicators. The general fertility rate (GFR) is more informative than the crude birth rate, but the database does not include births by age of mother; therefore, the total fertility rate cannot be calculated directly. Crude death rates are strongly influenced by age structure; they are used descriptively rather than as a principal indicator in the DVI. Infant mortality may show annual volatility in counties with small numbers of births.

The fourth limitation is inherent in composite indices. Indicator selection, normalization, and weighting involve normative decisions. Equal weighting promotes transparency, but it does not imply that all mechanisms have exactly the same causal importance. The robustness tests nevertheless indicate that the main results are stable under alternative specifications.

The fifth limitation concerns territorial scale. Counties are appropriate for long-term national comparisons, but they conceal urban-rural and intra-county differences. A county may simultaneously contain a dynamic urban pole and municipalities or communes experiencing severe depopulation. The results should therefore not be automatically extrapolated to localities or individuals.

CONCLUSIONS

The 1992-2025 analysis reveals a profound structural transformation of Romania's population. Although the population by domicile declined by 6.29% nationally, the strongest signal comes from changing intergenerational relations: the share of the population aged 65+ increased from 11.0% to 18.7%, the ageing index rose from 48.7 to 135.4, and the 15-24/55-64 generational replacement ratio fell from 156.4 to 78.7. At the same time, the general fertility rate declined and the natural balance deteriorated.

The proposed composite index captures these mechanisms without directly incorporating depopulation. The most vulnerable counties in 2025 are Brăila, Hunedoara, Caraş-Severin, Teleorman, and Tulcea, while Ilfov stands out as the least vulnerable, followed by Suceava, Iaşi, and Bistriţa-Năsăud. The distribution confirms the existence of broad clusters of vulnerability in the south, south-west, and south-east, as well as strong intraregional contrasts.

The very strong relationship between the mean DVI and cumulative population loss, together with the stability of rankings under alternative methods, supports the validity of the index as a comparative tool. Nevertheless, it should be interpreted as a synthetic measure of demographic vulnerability rather than as a causal estimator or a general development index.

The main implication is that uniform demographic policies have limited capacity to address such divergent territorial trajectories. Counties characterized by severe ageing and persistent natural population deficits require policies aimed at adaptation and the maintenance of territorial functions; counties with younger structures but intense migration require retention policies; and metropolitan areas need policies for managing population redistribution. Romania's demographic vulnerability is therefore fundamentally a matter of structure, mobility, and territorial inequality, not merely population size.

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