



# The influence of the built-to-natural environment continuum on the life satisfaction of the older adult population in Europe

Dhanalakshmi Tamatam<sup>1</sup> · Magdaléna Pichlerová<sup>2</sup> · Mayanka Ambade<sup>3</sup> · Ibrahimu Mdala<sup>4</sup> · Matthew North<sup>5</sup> · Ioan Vasile Abrudan<sup>6</sup> · Andrea Rosario Proto<sup>7</sup> · Roman Sitko<sup>1</sup> · Radim Boháček<sup>8</sup> · Hassabelrasoul Abdelrahman Mohamed Saeed<sup>1</sup> · Daniel Halaj<sup>1</sup> · Viliam Pichler<sup>1</sup>

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## Abstract

Ageing well, frequently evaluated through life satisfaction (LS), is a universal aim for societies, and is a particularly pressing concern in Europe with its growing older adult population. LS is linked to the surrounding environment through responses to ecological system changes, as described by the ecological theory of ageing. Previous research primarily focused on either built or natural environments separately. This study examines the effects of dwelling size (proximal factor), degree of urbanicity (intermediate factor), and forest coverage and weather-related loss events (distal factors) within the physical environment continuum on the LS of older adults across 25 European Union countries and Switzerland ( $N=23,596$ ). A two-level mixed model analysis, adjusted for relevant control variables, was conducted using individual-level data from the 8th wave of the Survey of Health, Ageing, and Retirement in Europe, NUTS 3-level data for forest coverage, and country-level data for climate risk. The results indicate positive associations between LS and dwelling size, degree of urbanicity, and forest coverage. Between-country variation accounted for approximately 5% of the variance in LS, and climate risk showed no significant association with LS. The countries were allocated to a statistically significant number of clusters according to the relationship between the degree of urbanicity and LS. Analysing built and natural environments as a continuum can inform policies to support LS in older adults.

**Keywords** Older adult population · Life satisfaction · Physical environmental continuum · Ecological theory of ageing · Europe

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Mayanka Ambade deceased 26 January, 2025.

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Extended author information available on the last page of the article

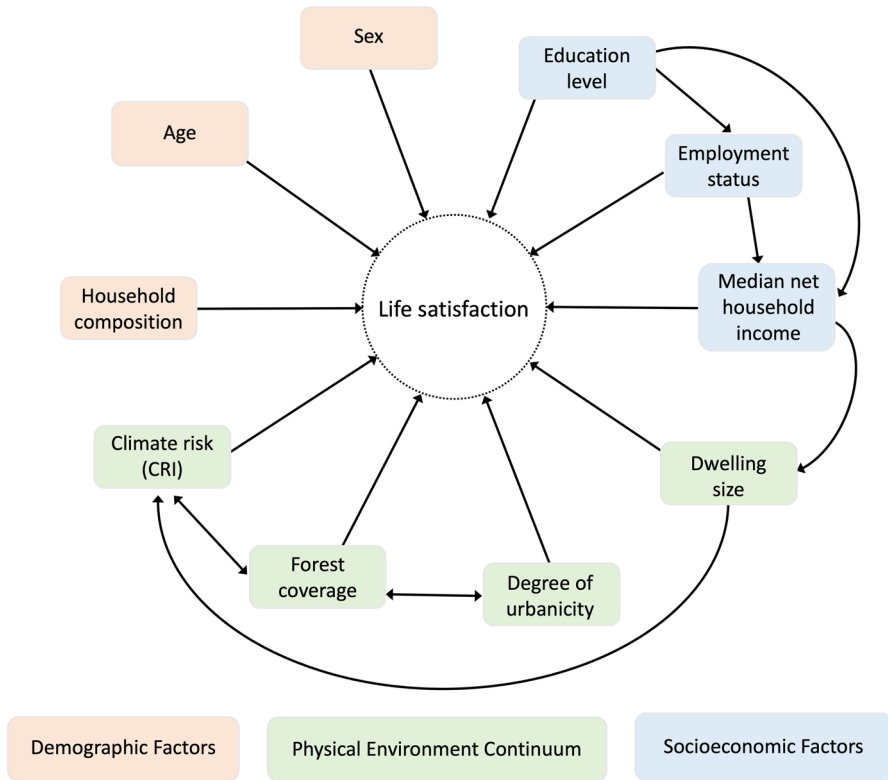
## Introduction

The share of older adults aged 60 years and above is expected to increase from 12 to 22% of the global population by 2050 (WHO, 2021). Europe, with a population of approximately 449 million and one-fifth of its residents aged 65 years or older (Eurostat, 2020), is already experiencing this change. A universal aim for ageing societies is successful ageing or ageing well (Kendig et al., 2014), meaning that older people remain healthy or follow a “healthy lifestyle”, stay functionally independent, engaged in life (e.g., achieving goals, social engagement), and show adaptive coping (e.g., mental toughness, compensation) (Reker, 2009; Rowe & Kahn, 1997; Waddell et al., 2025). An important indicator of successful ageing well is life satisfaction (LS) (Pan et al., 2019; Whitley et al., 2016; Wu & Cai, 2025) as a crucial subjective well-being (SWB) constituent (Cho et al., 2015; Diener et al., 1999). Ageing well is fundamentally tied to the neighbouring environment through adaptive responses to changes within the ecological system, as elaborated by the ecological theory of ageing (ETA) (Lawton & Nahemow, 1973; Wahl et al., 2012). Previous research mostly focused on the relationship between LS and the built environment, both internal and external, or outdoor spaces, typically up to the neighbourhood level (D’Alessandro et al., 2020; Riva et al., 2022; Torresin et al., 2022; Wahl et al., 2012), or the effects of the natural environment (Ambrey & Fleming, 2011; Biedenweg et al., 2017). At the same time, Prati (2024) suggested that relationships between LS and a single environment-related factor, such as the degree of urbanicity (DoU), may have a limited practical significance. Although ETA was originally mainly concerned with the physical space limited to indoor or built environments, this space can and should be extended to include both living space and natural environments as an important step from the ecological perspective (Coolen, 2006; Dunlap & Catton, 1983). Recent research (John et al., 2023; Wennberg et al., 2018) highlights opportunities for broadening the scope of ETA through the inclusion of neighbourhood green spaces, forests, and even wilderness. Studies integrating various environments into a physical environmental continuum (PEC) are likely to better account for the level of life space mobility of older adults (Wang et al., 2024), the related movement across PEC components, as well as for their mutual synergies or potential buffering capacities, especially in view of the overarching effect of climate change across the whole PEC. For example, a better quality of the broader environment can partially offset some of the negative effects of suboptimal housing quality— and vice versa—on SWB (Engineer et al., 2021; Jones-Rounds et al., 2014; Keller et al., 2022). Specifically, dwellings in both urban and rural areas can connect to the natural environment with varying degrees of immediacy, depending on the proximity of one’s dwelling to natural elements (Keniger et al., 2013), such as through viewing greenery from the windows of a building (D’Alessandro et al., 2020; Labib et al., 2022), spending time in or passing through neighbourhoods with green spaces such as gardens, enjoying shade and cooler temperatures provided by parks or urban forests (Ebenberger & Arnberger, 2019), and performing various activities in natural zones and forests (Výboštok et al., 2024). Sørensen (2021) found that access to nature increases LS in the rural areas of developed countries.

The objective of this study was to analyse the concurrent influence of several essential and spatiotemporally interconnected PEC components on the LS of older adults as a vulnerable population segment across 25 European Union countries and Switzerland. We examined associations between LS and dwelling size (DS) (a proximal factor), DoU (an intermediate factor), as well as forest coverage (FCO) and climate risk index (CRI) (Eckstein et al., 2021) (distal factors) within PEC. The model was adjusted for other relevant domains and variables, such as education, employment, and income, which are significant LS determinants. As a novel element, it included relatively objective distal environment indicators which have not been used in contextualised cross-country studies before: the country-level CRI, and FCO at the NUTS 3 level (EU Nomenclature of Territorial Units for Statistics; Eurostat, 2024) (EEA, 2018). The main research question was whether DS, DoU, FCO, and CRI simultaneously affect the LS of older adults in Europe when adjusted for relevant control variables. Our working hypothesis was that all four factors—DS, DoU, FCO, and CRI—significantly influence the LS of the European older adult population.

## Conceptual framework

Our approach integrates relevant LS's physical, demographic, and socio-economic dimensions through the ecological perspective as conceptualised through ETA, with an emphasis on physical space (Wahl et al., 2012). At the same time, it extends the physical space, originally understood as the built environment (Lawton & Nahemow, 1973; Wahl et al., 2012), by including both rural and natural environment components. The extension reflects an increased life space mobility that captures the spatial extent of an individual's movement, ranging from the room where the person sleeps to locations beyond their hometown (Fristedt et al., 2022). Life-space mobility is facilitated by economic development, technological innovations (e.g., communication and navigation technologies), expanded transportation options, and social engagement (Wang et al., 2024). As a result, the boundaries among distinct PEC components, ranging from one's room, home, and neighbourhood to rural and natural environments have become less rigid. At the same time, the whole PEC has been increasingly affected through the global climate change marked by a temperature increase at an average rate of about +0.5 °C per decade since 1991 (WMO, 2022) and the frequency of extreme weather events, impacting many aspects of quality of life (QoL). For example, heat islands, manifested through high temperatures in urban areas surrounded by cooler rural landscapes, negatively affect LS (Meng et al., 2023). FCO is an important factor that may counter and mitigate such negative impacts. According to Newton et al. (2020), the share of the population living within 5 km of forest increased between 2000 and 2012 in most EU countries, and this trend probably continues. These multiple trends underscore the need to study LS within PEC rather than in isolation, as shown in the selection of studied variables and their aggregation into domains, presented in Fig. 1. PEC is characterised by a set of four explanatory variables. Their order, DS (given as the number of rooms), DoU, FCO, and CRI, reflects the immediacy of exposure to a given factor, ranging from *near* to *far from* the dependent variable under consideration in relation to



**Fig. 1** Variables used in the study with arrows indicating the presumed direction of influence

space and time (Morris et al., 2017). Consequently, PEC begins with DS as the size of the dwellings, in which older adults spend most of their time. While there is a positive association between the living space size and LS, this effect may also partly derive from having more space than others, rather than simply having more space itself (Foye, 2017). From DS, PEC then continues along the urban–rural gradient, expressed through DoU, bounded by cities featuring a high density of dwellings and population density, and by forests with no or few settlements within them, featuring a high degree of naturalness, represented through the FCO as the percentage of forest cover in this study. While rural environments usually contain more green restorative areas, potentially used for recreation, their population often has comparatively limited access to services. The transition from built to natural environments could improve mood and reduce anxiety; the opposite transition may have a reverse effect (Chen et al., 2024). Astell-Burt and Feng (2019) and John et al. (2023) found that living near areas with more than 30% tree canopy was associated with better mental and general health and thus, healthy ageing. The proximity to forests was also shown to facilitate forest visitation (Pichlerová et al., 2021). Finally, the effect of the changing climate, expressed through CRI as economic losses and fatalities due to extreme weather events (e.g., storms, floods, heat waves), was considered the most distal PEC influence in this study because of its mostly episodic and spatially constrained pat-

tern. Older people living in urban areas are particularly threatened by heat due to the lack of vegetation in densely built-up areas compared to those living in rural regions, even when accounting for limited infrastructure to cope with extreme heat (Fastl et al., 2024). At the same time, it must be noted that PEC can evolve and can also be considered an assemblage of organic and inorganic, technical and natural elements (Anderson & McFarlane, 2011). As confounders, the demographic factors include sex (SX), age (AG), and household composition (HC), defined as living with a partner or not. Socio-economic factors encompass education level (EL), labour market status (LMS), and household income (HI).

## Material and methods

### Source data

The individual-level data used in our analysis were extracted from the Survey of Health, Ageing, and Retirement in Europe project (SHARE) database, purposefully made available for further research (Börsch-Supan, 2022; Börsch-Supan et al., 2013). SHARE is a multidisciplinary, cross-national, and longitudinal panel dataset containing detailed individual-level information on objective and subjective health, socioeconomic status, family structure, work and retirement, social interactions, and cognitive functions of European adults aged 50 years and older. The SHARE data collection is based on computer-assisted personal telephone interviews, and is designed to generate a representative sample from each participating country. Most countries used a stratified multi-stage sampling design, in which the country was divided into several strata in the first step to represent geographical areas within the country. In the second step, primary sampling units such as municipalities or zip codes were drawn, often with a probability proportional to their size. Finally, individuals or households were drawn. The dataset utilised in this study was based on the eighth wave (2019–2020) of SHARE comprising Austria, Belgium, Germany, Denmark, Spain, France, Greece, Italy, Netherlands, Sweden, Czech Republic, Poland, Estonia, Hungary, Slovenia, Luxembourg, Croatia, Bulgaria, Cyprus, Finland, Latvia, Lithuania, Malta, Romania, Slovakia, and Switzerland. In addition, country-level CRI and NUTS 3-level FCO data sources were used for the analysis. CRI accounted for the climate change impact, reflecting natural hazard events and country rank based on several key indicators: number of deaths, deaths per 100 000 inhabitants, total economic losses in US dollars (adjusted for purchasing power parity), and losses per GDP unit (Eckstein et al., 2021). FCO was employed as a representation of the nature and forest proximity to subjects, using NUTS 3-level forest cover data available through the Forest Information System for Europe (EEA, 2018) that were subsequently merged with the SHARE data by means of the corresponding geographical information (Boháček et al., 2025). Finally, our analysis accounted for the total net HI obtained from SHARE, but then expressed as a proportion of the median monthly household net country income (MHNCI), equalised and adjusted for household size and countries' purchasing power differences. The MHNCI data were sourced from Eurostat (Eurostat, 2022). The originally extracted SHARE dataset comprised 47,733 observations. After

excluding respondents below the 60-year age threshold, the dataset contained 38,873 respondents. Complete information on all explanatory variables needed for the analysis was available for 23,596 respondents, the final sample used in our analysis.

### Outcome, explanatory, and control variables

Variables were selected based on the conceptual framework (Fig. 1). Individual-level LS was selected as the outcome variable as it is a valid and reliable SWB measure (Clark, 2016; Diener et al., 1999; Lelkes, 2006). The LS measure was obtained from the SHARE database through a single-item question using an 11-point scale: "On a scale from 0 to 10, where 0 means completely dissatisfied and 10 means completely satisfied, how satisfied are you with your life?". We treated LS as a continuous variable, following the approach of Kalmijn (2013), Kim et al. (2021), Brokešová et al. (2021), de Vries et al. (2023), and others to allow for discerning LS values within the expectedly narrow range of population data and to ensure comparability with other research.

Explanatory variables represented the PEC factors. DS as an indicator of housing quality was assessed using the number of rooms in the dwelling, including bedrooms, but excluding kitchen, bathrooms and hallways. This variable was further categorised into four intervals: one to two rooms, three to four rooms, five to seven rooms, and eight or more rooms. DoU was extracted from the SHARE database, where it was asked, "How would you describe the area where you live?" with the options as "a big city, the suburbs or outskirts of a big city, a large town, a small town or a rural area or village". We have re-categorised it further into an urban city or suburb, a large or small town, and a village or rural area. The NUTS 3 level FCO (%) was categorised from 0–20% to 80–100%, with 20% increment. The country-level CRI represented the 2000–2019 period, and it was categorised into low (0–60), moderate (61–120), and high (121–180) intervals. Since CRI is based on ranks, lower CRI values indicate higher nominal ranks and, thus, higher climate risks.

The control variables included AG and SX as demographic factors. A dummy for SX and a categorical variable for AG (years) were included: 60–65, 66–70, 71–75, 76–80, 81 and over. Socio-economic factors were represented by several variables. They included EL categories derived from the International Standard Classification of Education (ISCED) (UNESCO, 2003): no education to lower secondary education (no education and ISCED 1 and 2), secondary education or higher (ISCED 3–6), and still in education or other. They also include LMS registered in four categories: working, unemployed, retired, or other working situations. HI, regarded as the socio-economic variable of paramount importance, was normalised according to MHNCI and divided into six categories from 0 to 5, namely <0.4, 0.4–0.8, 0.8–1.5, 1.5–3.0, 3.0–6.0, and >6 MHNCI. Inclusion of this variable was important to account for the absolute household income differences among countries. The final control variable was HC, approximated by an indicator of whether the individual is currently living with a partner or alone. Table 1 gives the relative population frequencies according to physical environmental factors across selected demographic and socio-economic groups.

## Statistical analyses

We employed a two-level random-intercept linear regression approach (Bryan & Jenkins, 2013) to examine the impact of various individual-level characteristics and one country-level characteristic on LS. The explanatory and control variables were screened for multicollinearity using the variance inflation factor. The variance partition coefficient (VPC) was used to assess the proportion of total LS variance attributable to between-country differences. The Wald chi-square statistic was used to assess the joint significance of the fixed-effect predictors in the following model:

$$LS_{ic} = a + \beta_1 DS_{ic} + \beta_2 DoU_{ic} + \beta_3 FCO_{ic} + \gamma CRI_c + \beta_4 AG_{ic} + \beta_5 SX_{ic} + \beta_6 HC_{ic} + \beta_7 EL_{ic} + \beta_8 LMS_{ic} + \beta_9 HI_{ic} + u_c + \varepsilon_{ic},$$

where  $\beta$  and  $\gamma$  denote regression coefficients at the individual (i) and country (c) levels, respectively, *LS* represents life satisfaction, *DS* denotes dwelling size, *DoU* captures the degree of urbanicity, *FCO* indicates forest coverage, *CRI* refers to the climate risk index, *AG* corresponds to age, *SX* to sex, *HC* to household composition, *EL* to education level, *LMS* to labour market status, and *HI* to household income, in line with abbreviations used across the text. Finally,  $u_c$  and  $\varepsilon_{ic}$  represent unobserved country and individual effects, respectively. Both random components are assumed to be normally distributed with a mean of 0 and variances  $\sigma_c^2$  and  $\sigma_\varepsilon^2$  between countries and individuals, respectively. The regression results were presented as model-estimated  $\beta$  and  $\gamma$  coefficients alongside their SE, *P*, and 95% CIs, as common in multiple regression (Valveny & Gilliver, 2016). The analysis was performed using Stata SE 17 (StataCorp, 2021). The map showing older adults' LS across European countries was created using Wolfram Mathematica 13 (Wolfram Research, 2021). For the subgroup analysis and classification of European countries into distinct clusters based on the relationship between LS and DoU, expressed through country-specific regression coefficients ( $B_c$ ), the natural breaks optimisation method was used (Jenks, 1977). To avoid the arbitrariness in the number of clusters—a common drawback of clustering methods—we employed a technique for implementing a statistically significant number of data classes in the Jenks algorithm (North, 2009). Results were considered significant when  $P < .05$ .

## Results

Figure 2 provides an overview of LS in older adults in 26 European countries in 2019/2020 on a scale from 0 to 10. The average values ranged from 8.7 (highest) in Denmark to 6.8 (lowest) in Bulgaria.

### Physical environment continuum and life satisfaction

The results of the two-level regression analysis of the PEC factors on LS, adjusted for control variables, are presented as the model estimates of the  $\beta$  and  $\gamma$  coefficients,

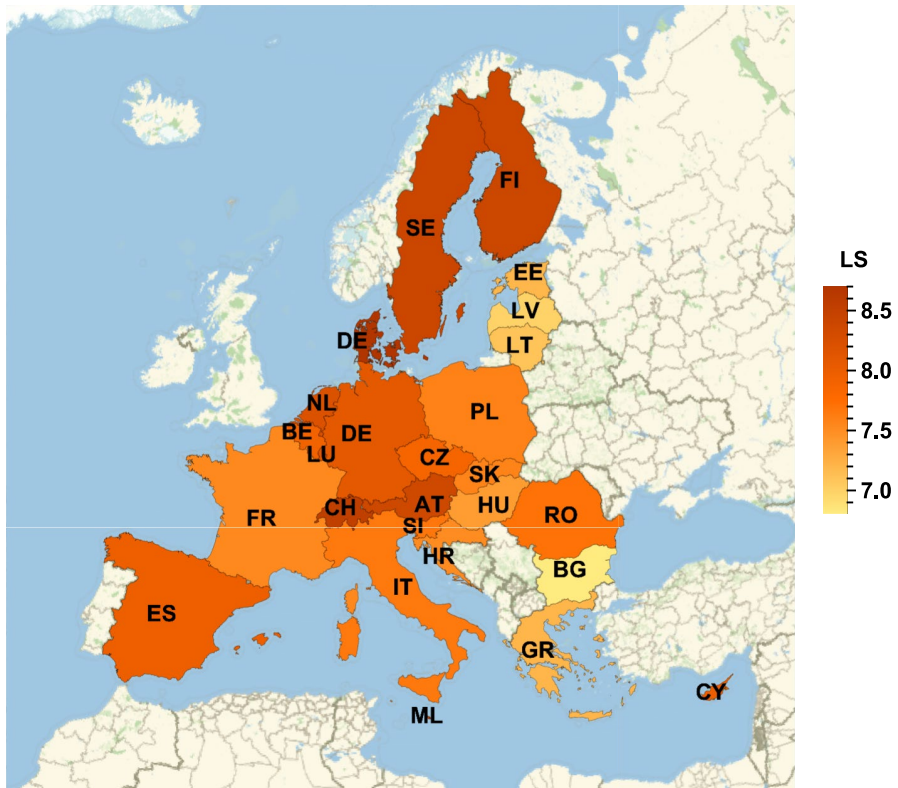
**Table 1** Relative frequencies (row percentage) in the population sample according to physical environment continuum (PEC) factors

	Climate risk index (country rank)			Forest cover (NUTS3, %)					Dwelling size (number of rooms)				
	Low	Medium	High	0–20	21–40	41–60	61–80	81–100	1–2	3–4	5–7	>8	
Age													
60–65	18.24	42.32	39.43	31.44	33.19	22.72	10.73	1.92	18.26	48.04	30.15	3.55	
66–70	19.33	41.19	39.47	28.75	32.12	23.46	13.61	2.07	19.08	49.47	28.42	3.03	
71–75	22.45	40.20	37.35	27.12	33.14	23.52	13.86	2.36	18.57	50.50	28.07	2.86	
76–80	23.91	35.40	40.68	24.86	31.98	24.97	15.69	2.50	21.54	51.76	24.41	2.29	
81–max	24.83	34.73	40.44	25.13	32.18	26.23	14.59	1.87	27.14	50.97	19.71	2.18	
Household composition													
Living with a partner	20.04	39.62	40.34	28.61	32.59	23.14	13.49	2.17	14.17	50.91	31.44	3.48	
Living alone	24.33	38.30	37.37	26.09	32.53	25.76	13.56	2.06	33.79	48.10	16.57	1.54	
Education level													
ISCED 0–2	18.33	39.06	42.61	29.81	32.70	23.86	11.51	2.12	26.60	52.63	19.17	1.59	
ISCED 3–6	22.68	39.18	38.13	27.01	32.44	24.13	14.28	2.13	18.20	78.92	29.54	3.34	
Others	17.59	50.93	31.48	22.22	49.38	14.81	11.11	2.47	18.52	57.41	21.30	2.78	
Labour market status													
Retired	21.60	38.59	39.81	24.45	33.44	24.54	15.09	2.48	22.23	49.97	25.45	2.35	
Working	29.01	39.84	31.15	32.43	27.94	23.70	14.04	1.89	14.06	47.33	33.61	5.00	
Unemployed	16.33	42.35	41.33	31.41	29.17	25.64	11.86	1.92	26.02	42.09	29.59	2.30	
Others	14.92	41.30	43.79	41.68	32.25	21.27	4.38	0.42	20.57	50.00	26.59	2.84	
Household income given as MHNCI proportion													
0 (<0.4)	25.94	47.02	27.04	14.45	37.00	35.37	12.96	0.21	44.77	45.13	9.26	0.84	
1 (0.4–0.8)	24.79	46.64	28.56	21.19	37.06	30.01	10.98	0.75	29.11	52.93	16.72	1.25	
2 (0.8–1.5)	18.40	32.38	49.22	33.22	26.06	23.77	14.47	2.48	16.69	56.37	24.48	2.47	
3 (1.5–3.0)	19.66	33.92	46.42	35.97	27.46	16.05	16.03	4.50	6.44	48.79	40.70	4.06	
4 (3.0–6.0)	15.65	41.84	42.51	35.88	38.89	11.63	11.47	2.13	7.92	35.27	49.12	7.69	
5 (>6.0)	24.13	34.08	41.80	23.37	43.03	18.17	13.76	1.78	14.03	48.55	32.37	5.05	
Degree of urbanicity													

**Table 1** (continued)

	Climate risk index (country rank)			Forest cover (NUTS3, %)					Dwelling size (number of rooms)				
	Low	Medium	High	0–20	21–40	41–60	61–80	81–100	1–2	3–4	5–7	> 8	
Urban (big cities and suburbs)	22.77	44.63	32.61	36.58	30.56	19.15	12.83	0.87	24.63	53.06	20.42	1.88	
Semi-urban (large and small towns)	23.42	39.68	36.90	28.22	31.42	22.51	15.29	2.56	21.10	49.72	26.60	2.58	
Rural or villages	18.02	34.47	47.51	21.21	35.30	29.13	11.88	2.49	16.84	47.99	31.27	3.90	

*ISCED* International Standard Classification of Education  
*MHNCI* Median Household Net Country Income



**Fig. 2** Life satisfaction of older adults in the European countries with the country names shown as the respective countries ISO-codes

their SE,  $P$ , and 95% CIs (Table 2). In terms of DS, a proximal PEC component, living in 1–2 room and 3–4 room homes was associated with lower LS compared to homes with 5–7 rooms as a reference ( $\beta = -0.24$ ,  $P < .001$ , and  $\beta = -0.13$ ,  $P < .001$ , respectively).  $DS > 7$  rooms did not provide additional LS benefit ( $P > .10$ ). LS was also associated with DoU as an intermediate PEC factor. In comparison to urban settings, living in semi-urban and rural areas was associated with lower LS ( $\beta = -0.06$ ,  $P = .027$ , and  $\beta = -0.13$ ,  $P < .001$ , respectively). Finally, the positive and significant LS association with living in regions featuring 60–80% FCO ( $\beta = 0.18$ ,  $P < .001$ ) suggests that even distal PEC components may support LS in later life. This relationship can be explained through visual exposure to forests, their restorative effects, air temperature regulation, and other spatially determined influences of forests. Interestingly, the positive association with LS was not significant for the 81–100% FCO category ( $\beta = 0.15$ ,  $P = .111$ ). Relative to the reference categories, the smallest DS showed the largest negative association with LS among the PEC factors, followed by a positive LS association with the second largest FCO (60–80%), and a negative association with the lowest DoU. No statistically significant association was found between LS and CRI, suggesting that recent country-level exposure to climate-related extreme events has not yet translated into measurable differences in LS among country popu-

**Table 2** Two-level regression of life satisfaction (LS) on environmental and housing variables with model-estimated  $\beta$  and  $\gamma$  regression coefficients at the individual and country levels, respectively

Factors	Estimates		SE	P	CI 95%	
	$\beta$	$\gamma$			Lower end	Upper end
Climate risk index (ref=high – 0–60)						
Moderate (61–120)		–0.22	0.17	>.10	–0.54	0.11
Low (121–180)		0.03	0.19	>.10	–0.34	0.41
Forest coverage (ref=0–20%)						
21–40%	0.00		0.04	>.10	–0.07	0.08
41–60%	0.00		0.04	>.10	–0.07	0.08
61–80%	0.18		0.05	<.001	0.08	0.29
81–100%	0.15		0.10	.111	–0.03	0.34
Degree of urbanicity (ref=urban, i.e. city, suburbs)						
Semi-urban (large and small towns)	–0.06		0.03	.027	–0.12	–0.01
Rural or villages	–0.13		0.03	<.001	–0.19	–0.07
Dwelling size (ref=5–7 rooms)						
1–2 rooms	–0.24		0.03	<.001	–0.31	–0.17
3–4 rooms	–0.13		0.03	<.001	–0.18	–0.08
>7 rooms	–0.10		0.06	>.10	–0.23	0.02
Gender (ref=male)						
Female	0.03		0.02	>.10	–0.01	0.07
Age (ref=71–75)						
60–65	–0.06		0.04	.083	–0.13	0.01
66–70	–0.03		0.03	>.10	–0.10	0.03
76–80	–0.07		0.03	.041	–0.14	–0.003
81–max	0.01		0.03	>.10	–0.06	0.08
Education level (ref=ISCED 0–2)						
ISCED 3–6	0.25		0.03	<.001	0.20	0.31
Still in school/Others	0.10		0.18	>.10	–0.25	0.45
Labour market status (ref=retired)						
Working	0.14		0.04	<.001	0.06	0.21
Unemployed	–0.59		0.10	<.001	–0.77	–0.40
Others	–0.21		0.04	<.001	–0.28	–0.14
Household income as MHNCI proportion (ref=0.8–1.5)						
0.0–0.4	–0.51		0.04	<.001	–0.59	–0.42
0.4–0.8	–0.30		0.03	<.001	–0.37	–0.23
1.5–3.0	0.07		0.03	.045	0.001	0.13
3.0–6.0	0.10		0.05	.034	0.01	0.19
>6	0.10		0.05	.060	–0.004	0.21
Household composition (ref=living with a partner)						
Living alone	–0.3		0.03	<.001	–0.37	–0.28
Constant	8.15		0.13	<.001	7.89	8.41
Number of respondents	23,596					
Number of groups	26					
Wald Chi-Square (27)	1151.72					
Prob>Chi-Square				<.001		

ISCED International Standard Classification of Education

MHNCI Median Household Net Country Income

lations. The significant associations between LS and the PEC factors are meaningful given the typically narrow range of LS values on the 0–10 scale, as well as when compared to the associations between LS and the control variables. In the latter cases, the estimated  $\beta$  coefficients reached the minimum value ( $-0.59$ ) for the unemployed category (relative to retired), and the maximum value of ( $0.25$ ) for the secondary and post-secondary education category (ISCED 3–6) vs. primary to lower-secondary education (ISCED 0–2). The pattern of adjusted associations supports the PEC framework as a viable conceptual tool for capturing gradations in environmental influence on LS across housing, settlement, and landscape contexts. Variation between countries accounted for only 4.76% of the total variance in LS ( $VPC=0.0476$ ), highlighting the predominance of individual-level factors in shaping LS in later life.

### Country clusters according to the degree of urbanicity

Since the two-level mixed linear model showed significantly lower LS in rural areas compared to urban areas, country-specific relationships between LS and DoU were used to group European countries into statistically significant clusters according to the respective regression coefficients for the association between LS and the urban vs. rural environments (Table 3) and between LS and the semi-urban vs. rural environments (Table 4). In both cases, six significant clusters emerged from the application of the Jenks breaks and the respective pseudocode for implementing a statistically significant number of data classes. Generally, the most populated clusters were those with country-specific  $B_c$  only slightly deviating from zero. These coefficients correspond to the estimated differences in LS between urban and rural residents within each country and were most common among EU longstanding member states such as Austria, the Netherlands, Spain, Italy, Denmark, Belgium, France, and Germany.

**Table 3** European countries clustered according to country-specific  $B_c$  coefficients representing associations between life satisfaction in the urban vs. rural environments as a reference

Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6	
Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$
Bulgaria	–	Sweden	–	Germany	–	Austria	–	Slovenia	0.23	Hungary	0.65
	0.41		0.15		0.09		0.01		0.01		
		Greece	–	France	–	Netherlands	0.02	Cyprus	0.21	Croatia	0.44
			0.20		0.03						
		Finland	–	Czech Rep	–	Spain	0.04			Lithuania	0.41
			0.15		0.07						
		Latvia	–	Luxembourg	–	Italy	0.07			Romania	0.47
			0.20		0.10						
						Denmark	–			Slovakia	0.35
							0.02				
						Switzerland	0.04				
						Belgium	0.12				
						Poland	0.12				
						Estonia	0.11				
						Malta	0.11				

**Table 4** European countries clustered according to country-specific  $B_c$  coefficients representing associations between LS in semi-urban vs. rural environments as a reference

Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6	
Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$	Country	$B_c$
Romania	– 0.38	Czech. Rep	– 0.09	Finland	0.01	Slovenia	0.15	Croatia	0.33	Latvia	0.50
Luxembourg	– 0.29	Germany	– 0.05	Italy	0.03	Poland	0.16				
Slovakia	– 0.28	Sweden	– 0.02	France	0.03	Austria	0.19				
Greece	– 0.21	Denmark	– 0.01	Cyprus	0.05	Hungary	0.21				
				Netherlands	0.06	Lithuania	0.25				
				Estonia	0.06	Malta	0.26				
				Spain	0.06						
				Switzerland	0.11						
				Belgium	0.11						
				Bulgaria	0.11						

A greater proportion of the EU newer member states, such as Slovenia, Hungary, Croatia, and Lithuania, appeared in clusters with more positive  $B_c$ , meaning larger differences in LS favouring urban or semi-urban residents over rural ones. The countries from the former group are mostly those with comparatively good accessibility to services in rural areas, both close to cities and remote, while countries from the latter group typically show the longest travelled distances to some basic but essential services (Kompil et al., 2022). There were also notable cases of countries (Romania, Slovakia) showing comparatively large positive  $B_c$  for urban vs. rural environments (Table 3), but negative  $B_c$  for the associations between semi-urban vs. rural environments (Table 4). Both countries are characterised by the lowest percentage of the urban population and considerable rural–urban economic disparities, with most of the socio-economic development occurring in and around their capitals and big cities (Eurofound, 2023; Shucksmith et al., 2009).

## Discussion and conclusions

The narrow cross-country range of LS values aligns with the model proposed by Cummins (2003), which states that LS is under homeostatic control. Overall, the influence of proximal (DS), intermediate (DoU), and partly also distal PEC factors (FCO) on LS was found statistically significant and practically meaningful. Thus, our findings support the original hypothesis, except for CRI, which remains an incipient determinant of LS.

Our model identified DS as an influential factor of LS. However, for dwellings with eight or more rooms, the effect on LS was not statistically significant. Earlier, Oswald et al. (2011) established that apartment size was positively related to LS of

the 65–80 years old and negatively related in the 80+ group. Foye (2017) also found a weak positive relationship between DS and LS, but only for men. The latter author also suggested that space affects SWB through social status. We speculate that larger dwellings may facilitate better adaptation to the changing needs of older adults as they spend a comparatively higher proportion of time indoors and at home (Sattari et al., 2023; Wu et al., 2021). It is also possible that larger DS provides a certain buffering and serves as a substitute for outdoor spaces during periods of confinement to one's home due to adverse weather conditions, illness, major crises, or other constraining factors.

The LS of older adults was negatively associated with living in semi-urban and rural areas compared to living in urban areas (big cities and suburbs). Our results concur with a positive correlation between individual well-being and urbanicity within EU countries, recently established by Lenzi and Perucca (2021). Želinský et al. (2021) observed higher SWB among Slovak residents living in more densely settled areas. Other findings (Biagi & Meleddu, 2023), which accounted for the availability and accessibility of amenities and social relations, suggest that the likelihood of having higher LS in rural areas is only associated with living in wealthier rural places, where higher-ranked cities project accessibility and positive externalities. The detected urban–rural gradient in LS reflects the complexity of rural living, involving factors such as social isolation, limited access to services, and economic challenges, which may outweigh or even offset the benefits of rural environments (Milbourne, 2007). Although comparable information on the EU Cohesion Policy implementation by settlement type is limited for many newer Member States, the case of Poland (cluster 4), which allocated nearly 40% of its Cohesion Policy funds to rural areas with about 40% of its population (Komorowski et al., 2021) suggests that targeted investments may support more balanced development and smaller rural–urban LS gaps in this and other newer EU member states found in cluster 4. In contrast, “rural advantage” and “urban penalty”, common in low-income groups (Satterthwaite, 2007), was manifested through a strongly negative association between LS in urban vs. rural settings in the case of Bulgaria (cluster 1; Table 3), in line with an earlier study showing that Bulgarian city dwellers are less satisfied with their current lives than rural residents (OECD, 2020) and the fact that older adults in Bulgaria had the lowest HI before the SHARE wave 8 sampling (Eurostat, 2026). Relatedly, our two-level regression model showed a significant and strong negative LS association with the lowest HI category ( $<0.4$  MHNCI;  $\beta = -0.51$ ,  $P < .001$ ), compared to 0.8–1.5 MHNCI. The overall picture aligns with Shucksmith et al. (2009), who observed that urban–rural distinctions in the perceived QoL were minimal in the wealthier EU countries compared to Eastern and Southern EU countries.

Our results showed a significant positive association between the LS of older adults and the 60–80% FCO category, suggesting that this relationship may reflect pathways involving direct forest exposure and relative forest proximity (e.g., through visual contact, forest visits and restorative effects, climate moderation, forest-derived social and economic benefits or other mechanisms). The existing information on how FCO affects LS is not unequivocal. Recently, Jang et al. (2019) found that LS depends on forest visit frequency rather than forest proximity, while Pichlerová et al. (2021) established an association between forest visit frequency and FCO. Jensen and Koch

(2004) and Mizaras et al. (2015) established that individuals are willing to walk to nearby recreational forests if the distance is less than 1–2 km. Relatedly, opportunities for forest visits, through which restorative effects can be obtained (Ježová et al., 2025; Lamatungga et al., 2024; Výboštok et al., 2024), may be particularly problematic for older adults in areas with relatively low FCO (Pichlerová et al., 2021). However, the positive association between LS and FCO was not significant ( $P=.111$ ) in regions with the maximum FCO (>80%). A plausible interpretation is that the remoteness of settlements in these regions partly attenuates the respective positive association. Specifically, greater remoteness of forest-dominated areas is often associated with limited access to services and infrastructure (EU Cap Network, 2023). In contrast, we did not find an association between LS and FCO for the lower FCO categories (20–60%). Overall, the results across FCO categories are consistent with prior work (Elands et al., 2004), indicating that local people report stronger perceptions of forest-derived benefits, including QoL, in traditional forest areas, characterised by higher FCO and longer forest continuity and history. However, only a very limited amount of research can be used for a direct comparison with our analysis. Furthermore, much of the previous research was either locally focused, concerned with SWB as a broader measure compared to LS, or used coarser (country-level) nature or FCO data. In this framework, our novel results generally relate to findings that nature proximity supports higher SWB among rural dwellers compared to the urban population in developed EU countries (Sørensen, 2014, 2021) and that people living in greener neighbourhoods report higher SWB (White et al., 2021). At the same time, our study deviates from the results suggesting that, on the global scale, FCO (country-level) does not significantly affect LS (Kessler et al., 2019). Therefore, data with a sufficient spatial resolution are needed to understand the nature of the LS–forest cover association. Notably, when using country-level data instead of NUTS 3 FCO data in our two-level model, the results were also non-significant (not shown). The European-scale evidence that LS of the older adults is positively associated with a relatively large FCO, derived from the presented study, can aid land and forest planning to make forests accessible for the whole population, including older adults. Availability of forests as restorative environments is crucial during global public health crises, as manifested in the case of COVID-19 pandemic (Pichlerová et al., 2021). This may also hold in other instances when populations experience acute anxiety and mental health impact resulting from events like international conflicts, even when their countries are not directly involved in or exposed to a war (Kalaitzaki et al., 2024).

Forests can also mitigate the impact of changing climate and heat waves on SWB (Ebenberger & Arnberger, 2019). But contrary to the fact that 93% of European citizens surveyed by Eurobarometer (2021) consider climate change to be a serious problem, our analysis did not reveal a meaningful or significant effect of the past climate risk record (2000–2019) on the LS of older adults in Europe. We deduce that while Europe, especially its southern and eastern regions, exhibited the highest number of recorded heat waves in the decade of 2011–2021 (Boboc et al., 2025), the expected effect of major heatwaves that hit Europe in 2003, causing increased mortality mainly in older adults (Ballester et al., 2023), had faded over time. The discomfort resulting from milder climate risk events was probably absorbed owing to

a relatively high coping capacity typical in older adults (Pichlerová et al., 2023). The latter factor, coupled with a sufficient DS, may provide a buffer capacity for adapting to hot weather through effective ventilation, spending time in rooms less exposed to solar irradiation, or meaningful activities that help maintain thermal comfort. Similar behaviours were shown to be relevant for the SWB of older adults (Lin et al., 2023; Williams et al., 2019). Finally, it cannot be excluded that CRI impact was partly masked by the DoU and FCO, affecting LS through better availability of cooling infrastructure in the cities and forest shade in rural areas, respectively. Nevertheless, significant associations may be found in countries that may be moving further away from the preferred climate (Rehdanz & Maddison, 2005).

Despite the contributions of this analysis, it is not without its limitations. While our study utilised individual-level data for DoU and DS alongside NUTS3-level FCO data, it relied on country-level data for CRI, which may have obscured its relevance as an emergent factor. Although climate risk can currently be considered an incipient factor of LS, the link warrants monitoring and further research given the predicted 1.5 °C temperature increase and accelerated impact (Harper, 2023). It is, therefore, essential that questions concerning the impact of climate change and access to restorative environments enrich future individual-level surveys. In addition, it cannot be excluded that the FCO influence on LS competed with the proximity of blue spaces (e.g., seaside or inland water bodies such as lakes and rivers), unaccounted for in this study but offering comparable SWB benefits (White et al., 2021). The clustering of countries by the DoU – LS association achieved in this study may aid targeted and better integrated housing, land, forest, and public health policies and interventions at both European and national levels aimed at enhancing living conditions and LS in rural areas, particularly in newer EU member states. For instance, improvements in public transportation would tap into the currently underutilised potential of the relatively high forest proximity in Europe with considerable restorative potential. Older adults' ability to make qualified and timely decisions on their future housing can be strengthened by raising their awareness about the dwelling size associated with the highest LS (i.e., 5–7 rooms per average household).

This study aimed to address the gap in understanding how wider physical environment factors influence the LS of the older adult population in 25 EU countries and Switzerland. The analysis accounted for other LS determinants, including demographic and socio-economic factors like HI adjusted to country-specific medians. The two-level regression analysis revealed significant associations between LS and the proximal, intermediate, and one of the two distal PEC factors, namely DS, DoU, and FCO. No effect of CRI as the only country-level factor on LS was detected. Overall, between-country variation accounted for approximately 5% of the variance in LS. Our results highlight the need for future research employing more detailed, localised data to explore these relationships further, particularly in regions experiencing significant climate shifts. The results underscore the utility of studying LS within the built-to-natural environment continuum. Additionally, the presented study provides a reliable clustering of the European countries based on such a relationship. The findings offer actionable insights for coordinated policies and interventions targeting housing quality and both DoU gradient and FCO patterns aimed to improve LS, SWB and the overall QoL of the older adult population in Europe.

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**Author Contributions** • Conceptualization: [Dhanalakshmi Tamatam], [Magdaléna Pichlerová], [Vilím Pichler]; Methodology: [Dhanalakshmi Tamatam], [Ibrahim Mdala], [Mayanka Ambade], [Matthew North], [Vilím Pichler]; Formal analysis and investigation: [Dhanalakshmi Tamatam], [Ibrahim Mdala], [Mayanka Ambade], [Matthew North], [Vilím Pichler]; Writing—original draft preparation: [Dhanalakshmi Tamatam]; Writing – review and editing: [Mayanka Ambade], [Matthew North], [Vilím Pichler], [Magdaléna Pichlerová], [Daniel Halaj], [Hassabelrasoul Saeed], [Andrea Rosario Proto], [Radim Boháček], [Ioan Vasile Abrudan]; Funding acquisition: [Magdaléna Pichlerová], [Radim Boháček]. All authors have read and agreed to the published version of the manuscript.

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**Data availability** The individual-level data that support the findings of this study are available from the SHARE Research Data Center website ([www.share-project.org](http://www.share-project.org)) after completion of the registration and the acceptance of the credentials. The country- and NUTS 3-level data are obtainable from the cited references.

## Declarations

**Ethics and consent to participate** The implementation of SHARE in the participating countries was reviewed and approved by the respective institutional review boards or ethics committees whenever this was required. All SHARE respondents gave their informed consent to be included in the SHARE study.

**Conflict of interest** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## References

- Ambrey, C. L., & Fleming, C. M. (2011). The influence of natural environment and climate on life satisfaction in Australia. Discussion Paper No. 2011–01, Brisbane: Griffith University. Discussion Paper No. 2011–01, Griffith University, Brisbane. <https://doi.org/10.22004/ag.econ.100548>
- Anderson, B., & McFarlane, C. (2011). Assemblage and geography. *Area*, 43(2), 124–127. <https://doi.org/10.1111/J.1475-4762.2011.01004.X>
- Astell-Burt, T., & Feng, X. (2019). Association of urban green space with mental health and general health among adults in Australia. *JAMA Network Open*, 2(7), e198209. <https://doi.org/10.1001/jamanetworkopen.2019.8209>
- Ballester, J., Quijal-Zamorano, M., Méndez Turrubiates, R. F., Pegenaute, F., Herrmann, F. R., Robine, J. M., Basagaña, X., Tonne, C., Antó, J. M., & Achebak, H. (2023). Heat-related mortality in Europe during the summer of 2022. *Nature Medicine*, 29(7), 1857–1866. <https://doi.org/10.1038/s41591-023-02419-z>
- Biagi, B., & Meleddu, M. (2023). Exploring urban-rural paradox: Does going rural mean higher life satisfaction? *Italian Economic Journal*, 10, 795–823. <https://doi.org/10.1007/s40797-023-00248-0>
- Biedenweg, K., Scott, R. P., & Scott, T. A. (2017). How does engaging with nature relate to life satisfaction? Demonstrating the link between environment-specific social experiences and life satisfaction. *Journal of Environmental Psychology*, 50, 112–124. <https://doi.org/10.1016/j.jenvp.2017.02.002>
- Boboc, L., Dima, M., Vaideanu, P., & Ionita, M. (2025). Trends and variability of heat waves in Europe and the association with large-scale circulation patterns. *Weather and Climate Extremes*, 49, 100794. <https://doi.org/10.1016/j.wace.2025.100794>
- Boháček, R., Ferrari, I., Jirsa, D., & Pasini, G. (2025). geoSHARE 1.0: Geographic Information in Regular SHARE Waves. SHARE Working Paper Series 96–2025. SHARE ERIC.
- Brokešová, Z., Cupák, A., Lepinteur, A., & Rizov, M. (2021). Wealth, assets and life satisfaction: A metadata instrumental-variable approach. NBS Working Paper Series, 4, Research Department, National Bank of Slovakia. [https://www.nbs.sk/\\_img/documents/publik/wp\\_4\\_2021\\_wealth\\_assets\\_and\\_life\\_satisfaction\\_a\\_metadata\\_instrumental\\_variable\\_approach.pdf](https://www.nbs.sk/_img/documents/publik/wp_4_2021_wealth_assets_and_life_satisfaction_a_metadata_instrumental_variable_approach.pdf). Accessed 10 Jan 2025.
- Börsch-Supan, A. (2022). Survey of health, ageing and retirement in Europe (SHARE) Wave 8. Release version: 8.0.0. SHARE-ERIC. Data set. <https://doi.org/10.6103/SHARE.w8ca.800>.
- Börsch-Supan, A., Brandt, M., Hunkler, C., Kneip, T., Korbmacher, J., Malter, F., Schaan, B., Stuck, S., Zuber, S., SHARE Central Coordination Team. (2013). Data resource profile: The Survey of Health, Ageing and Retirement in Europe (SHARE). *International Journal of Epidemiology*, 42(4), 992–1001. <https://doi.org/10.1093/ije/dyt088>

- Bryan, M. L., & Jenkins, S. P. (2013). Regression analysis of country effects using multilevel data: A cautionary tale. *European Sociological Review*, 32(1), 3–22. <https://doi.org/10.1093/esr/jcv059>
- Chen, D., Yin, J., Yu, C. P., Sun, S. J., Gabel, C., & Spengler, J. D. (2024). Physiological and psychological responses to transitions between urban built and natural environments using the cave automated virtual environment. *Landscape and Urban Planning*, 241, 104919. <https://doi.org/10.1016/j.landurbplan.2023.104919>
- Cho, J., Martin, P., & Poon, L. W. (2015). Successful aging and subjective well-being among oldest-old adults. *The Gerontologist*, 55(1), 132–143. <https://doi.org/10.1093/geront/gnu074>
- Clark, A. E. (2016). SWB as a measure of individual well-being. In M. D. Adler & M. Fleurbaey (Eds.) *The Oxford Handbook of Well-Being and Public Policy* (online edn., 518–552), Oxford handbooks online, Oxford Academic. <https://doi.org/10.1093/OXFORDHOB/9780199325818.013.17>
- Coolen, H. (2006). The meaning of dwellings: An ecological perspective. *Housing, Theory and Society*, 23(4), 185–201. <https://doi.org/10.1080/14036090600909469>
- Cummins, R. A. (2003). Normative life satisfaction: Measurement issues and a homeostatic model. *Social Indicators Research*, 64(2), 225–256. <https://doi.org/10.1023/A:1024712527648>
- D'Alessandro, D., Gola, M., Appolloni, L., Dettori, M., Fara, G. M., Rebecchi, A., Settimo, G., & Capolongo, S. (2020). COVID-19 and living space challenge. Well-being and public health recommendations for a healthy, safe, and sustainable housing. *Acta Biomedica*, 91(9-S), 61–75. <https://doi.org/10.23750/abm.v91i9-S.10115>
- de Vries, S. P., Garcia Alvarez, G., Botzen, W. J. W., & Bockarjova, M. (2023). Valuing urban nature through life satisfaction: The consistency of GIS and survey indicators of nature. *Resource and Energy Economics*, 75, 101406. <https://doi.org/10.1016/j.reseneeco.2023.101406>
- Diener, E., Suh, E. M., Lucas, R. E., & Smith, H. L. (1999). Subjective well-being: Three decades of progress. *Psychological Bulletin*, 125(2), 276–302. <https://doi.org/10.1037/0033-2909.125.2.276>
- Dunlap, R. E., & Catton, W. R. (1983). What environmental sociologists have in common (whether concerned with “built” or “natural” environments). *Sociological Inquiry*, 53, 113–135. <https://doi.org/10.1111/j.1475-682X.1983.tb00030.x>
- Ebenberger, M., & Arnberger, A. (2019). Exploring visual preferences for structural attributes of urban forest stands for restoration and heat relief. *Urban Forestry & Urban Greening*, 41, 272–282. <https://doi.org/10.1016/J.UFUG.2019.04.011>
- Eckstein, D., Vera, K., & Schäfer, L. (2021). Global climate risk index 2021. Germanwatch. <https://www.germanwatch.org/en/19777>. Accessed 8 Oct 2022.
- EEA – European Environment Agency. (2018). MS\_ForestArea (FISE v1r1), EEA Discodata – Forest Information System for Europe. [https://discomap.eea.europa.eu/App/DiscodataViewer/?fq=5bFI5E%5d.%5bv1r1%5d.%5bMS\\_ForestArea](https://discomap.eea.europa.eu/App/DiscodataViewer/?fq=5bFI5E%5d.%5bv1r1%5d.%5bMS_ForestArea). Accessed 6 July 2025.
- Elands, B. H. M., O’Leary, T. N., Boerwinkel, H. W. J., & Wiersum, K. F. (2004). Forests as a mirror of rural conditions; Local views on the role of forests across Europe. *Forest Policy and Economics*, 6(5), 469–482. <https://doi.org/10.1016/j.forpol.2004.01.003>
- Želinský, T., Hudec, O., Mojsejová, A., & Hricová, S. (2021). The effects of population density on subjective well-being: A case-study of Slovakia. *Socio-Economic Planning Sciences*, 78, 101061. <https://doi.org/10.1016/j.seps.2021.101061>
- Engineer, A., Gualano, R. J., Crocker, R. L., Smith, J. L., Maizes, V., Weil, A., & Sternberg, E. M. (2021). An integrative health framework for wellbeing in the built environment. *Building and Environment*, 205, 108253. <https://doi.org/10.1016/j.buildenv.2021.108253>
- EU CAP Network. (2023). Supporting the needs of forest-dominant rural areas and municipalities: Laying the groundwork for a network under the forest strategy. [https://eu-cap-network.ec.europa.eu/thematic-groups-cap-implementation/supporting-needs-forest-dominant-rural-areas-and-municipalities-laying-groundwork-network-under\\_en](https://eu-cap-network.ec.europa.eu/thematic-groups-cap-implementation/supporting-needs-forest-dominant-rural-areas-and-municipalities-laying-groundwork-network-under_en). Accessed 25 Feb 2026.
- Eurobarometer. (2021). Special Eurobarometer 513, Climate change. <https://europa.eu/eurobarometer/surveys/detail/2273>. Accessed 17 May 2024.
- Eurofound. (2023). Bridging the rural–urban divide – Addressing inequalities and empowering communities, Publications Office of the European Union. <https://doi.org/10.2806/647715>. Accessed 10 Dec 2024.
- Eurostat. (2020). Ageing Europe, looking at the lives of older people in the EU; 2019. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing\\_Europe\\_-\\_looking\\_at\\_the\\_lives\\_of\\_older\\_people\\_in\\_the\\_EU](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_looking_at_the_lives_of_older_people_in_the_EU). Accessed 8 Oct 2022.

- Eurostat. (2022). Living conditions in Europe - income distribution and income inequality - Statistics Explained. [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living\\_conditions\\_in\\_Europe\\_-\\_income\\_distribution\\_and\\_income\\_inequality](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_income_distribution_and_income_inequality). Accessed 10 Apr 2023.
- Eurostat. (2024). NUTS - Nomenclature of territorial units for statistics. <https://ec.europa.eu/eurostat/web/nuts>. Accessed 10 Jul 2025.
- Eurostat. (2026). Mean and median income by age and sex. [https://ec.europa.eu/eurostat/databrowser/view/ILC\\_DI03\\_\\_custom\\_4622063/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/ILC_DI03__custom_4622063/default/table?lang=en). Accessed 16 Feb 2026.
- Fastl, C., Arnberger, A., Gallistl, V., Stein, V. K., & Dorner, T. E. (2024). Heat vulnerability: Health impacts of heat on older people in urban and rural areas in Europe. *Wiener Klinische Wochenschrift*, 136(17–18), 507–514. <https://doi.org/10.1007/s00508-024-02419-0>
- Foye, C. (2017). The relationship between size of living space and subjective well-being. *Journal of Happiness Studies*, 18(2), 427–461. <https://doi.org/10.1007/s10902-016-9732-2>
- Friedstedt, S., Kammerlind, A. S., Fransson, E. I., & Ernsth Bravell, M. (2022). Physical functioning associated with life-space mobility in later life among men and women. *BMC Geriatrics*, 22(1), 364. <https://doi.org/10.1186/s12877-022-03065-9>
- Harper, S. (2023). The implications of climate change for the health of older adults. *Journal of Population Ageing*, 16(3), 565–568. <https://doi.org/10.1007/s12062-023-09425-6>
- Jang, Y. S., Yoo, R. H., & Lee, J. H. (2019). The effects of visit characteristics in neighborhood forest on individual life satisfaction. *Journal of People, Plants, and Environment*, 22(6), 677–690. <https://doi.org/10.11628/ksppe.2019.22.6.677>
- Jenks, G. (1977). Optimal data classification for choropleth maps. Occasional Paper No. 2, Department of Geography, University of Kansas.
- Jensen, F. S., & Koch, N. E. (2004). Twenty-five years of forest recreation research in Denmark and its influence on forest policy. *Scandinavian Journal of Forest Research*, 19(4), 93–102. <https://doi.org/10.1080/14004080410034173>
- Ježová, D., Hlaváčová, N., Karailieová, L., Lamatungga, K. E., Halamová, J., Tamatam, D., Pichlerová, M., & Pichler, V. (2025). Reduced hair cortisol concentrations are associated with improved emotional wellbeing in older adults following repeated forest walking. *Scientific Reports*, 15, 22087. <https://doi.org/10.1038/s41598-025-08378-4>
- John, E. E., Astell-Burt, T., Yu, P., Brennan-Horley, C., & Feng, X. (2023). Green space type and healthy ageing in place: An Australian longitudinal study. *Urban Forestry & Urban Greening*, 84, 27903. <https://doi.org/10.1016/j.ufug.2023.127903>
- Jones-Rounds, M. L., Evans, G. W., & Braubach, M. (2014). The interactive effects of housing and neighbourhood quality on psychological well-being. *Journal of Epidemiology and Community*, 68(2), 171–175. <https://doi.org/10.1136/jech-2013-202431>
- Kalaitzaki, A., Goodwin, R., Kurapov, A., Vintila, M., Lazarescu, G., Lytvyn, G. S., Tsouvelas, G., Tamialaki, A., et al. (2024). The mental health toll of the Russian-Ukraine war across 11 countries: Cross-sectional data on war-related stressors, PTSD and CPTSD symptoms. *Psychiatry Research*, 342, 116248. <https://doi.org/10.1016/j.psychres.2024.116248>
- Kalmijn, W. (2013). From discrete 1 to 10 towards continuous 0 to 10: The continuum approach to estimating the distribution of happiness in a nation. *Social Indicators Research*, 110(2), 549–557. <https://doi.org/10.1007/s11205-011-9943-1>
- Keller, A., Groot, J., Matta, J., Bu, F., El Aarbaoui, T., Melchior, M., Fancourt, D., Zins, M., Goldberg, M., Nybo Andersen, A. M., Rod, N. H., Strandberg-Larsen, K., & Varga, T. V. (2022). Housing environment and mental health of Europeans during the COVID-19 pandemic: A cross-country comparison. *Scientific Reports*, 12, 5612. <https://doi.org/10.1038/s41598-022-09316-4>
- Kendig, H., Browning, C. J., Thomas, S. A., & Wells, Y. (2014). Health, lifestyle, and gender influences on aging well: An Australian longitudinal analysis to guide health promotion. *Frontiers in Public Health* 2(70). <https://doi.org/10.3389/fpubh.2014.00070>
- Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, 10(3), 913–935. <https://doi.org/10.3390/ijerph10030913>
- Kessler, J., Ferreira, S., & Ahmadiani, M. (2019). What makes people happy? Explaining the cross-national variation of life satisfaction. In 2019 Annual Meeting, February 2.–5., 2019, Birmingham, Alabama 284330, Southern Agricultural Economics Association.
- Kim, E. S., Delaney, S. W., Tay, L., Chen, Y., Diener, E., & Vanderweele, T. J. (2021). Life satisfaction and subsequent physical, behavioral, and psychosocial health in older adults. *Milbank Quarterly*, 99(1), 209–239. <https://doi.org/10.1111/1468-0009.12497>











- Komorowski, Ł., Mróz, A., & Stanny, M. (2021). The spatial pattern of the absorption of cohesion policy funds in Polish rural areas. *Land*, 10(1), 26. <https://doi.org/10.3390/land10010026>
- Kompil, M., Jacobs-Crisioni, C., Perpiña Castillo, C. & Lavalle, C. (2022). Accessibility to services in Europe's member states – an evaluation by degree of urbanisation and remoteness. & Policy Brief. European Commission – Joint Research Centre, JRC124457. <https://publications.jrc.ec.europa.eu/repository/handle/JRC124457>. Accessed 3 Jan 2025.
- Labib, S. M., Browning, M. H. E. M., Rigolon, A., Helbich, M., & James, P. (2022). Nature's contributions in coping with a pandemic in the 21st century: A narrative review of evidence during COVID-19. *Science of the Total Environment*, 833(10), 155095. <https://doi.org/10.1016/J.SCITOTENV.2022.155095>
- Lamatungga, K. E., Pichlerová, M., Halamová, J., Kanovský, M., Tamatam, D., Ježová, D., & Pichler, V. (2024). Forests serve vulnerable groups in times of crises: Improved mental health of older adults by individual forest walking during the COVID-19 pandemic. *Frontiers in Forests and Global Change*, 7, 1287266. <https://doi.org/10.3389/ffgc.2024.1287266>
- Lawton, M. P., & Nahemow, L. (1973). Ecology and the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), *The psychology of adult development and aging* (pp. 619–674). American Psychological Association. <https://doi.org/10.1037/10044-020>
- Lelkes, O. (2006). Knowing what is good for you Empirical analysis of personal preferences and the “objective good.” *Journal of Socio-Economics*, 35(2), 285–307. <https://doi.org/10.1016/j.socec.2005.11.002>
- Lenzi, C., & Perucca, G. (2021). Not too close, not too far: Urbanisation and life satisfaction along the urban hierarchy. *Urban Studies*, 58(13), 2742–2757. <https://doi.org/10.1177/0042098020962397>
- Lin, Z., Chin, D. C. W., Fung, H. H., Lay, J. C., & Tse, D. C. K. (2023). Hot instantaneous temperature and affect: meaningful activities as a buffer for older adults with low socioeconomic status. *Innovation in Aging*, 7(6), igad057. <https://doi.org/10.1093/geroni/igad057>
- Meng, F., Yan, S., Tian, G., & Wang, Y. (2023). Surface urban heat island effect and its spatiotemporal dynamics in metropolitan area: A case study in the Zhengzhou metropolitan area, China. *Frontiers in Environmental Science*, 11, 1247046. <https://doi.org/10.3389/fenvs.2023.1247046>
- Milbourne, P. (2007). Re-populating rural studies: Migrations, movements and mobilities. *Journal of Rural Studies*, 23(3), 381–386. <https://doi.org/10.1016/j.jrurstud.2007.04.002>
- Mizaras, S., Kavaliauskas, M., Činga, G., Mizaraitė, D., & Belova, O. (2015). Socio-economic aspects of recreational use of forests in Lithuania. *Baltic Forestry*, 21(2), 308–314.
- Morris, G. P., Reis, S., Beck, S. A., Fleming, L. E., Adger, W. N., Benton, T. G., & Depledge, M. H. (2017). Scoping the proximal and distal dimensions of climate change on health and wellbeing. *Environmental Health*, 16(S1), 116. <https://doi.org/10.1186/s12940-017-0329-y>
- Newton, P., Kinzer, A. T., Miller, D. C., Oldekop, J. A., & Agrawal, A. (2020). The number and spatial distribution of forest-proximate people globally. *One Earth*, 3(3), 363–370. <https://doi.org/10.1016/j.oneear.2020.08.016>
- North, M. A. (2009). A method for implementing a statistically significant number of data classes in the Jenks algorithm. In *Sixth International Conference on Fuzzy Systems and Knowledge Discovery*, (pp. 35–38). <https://ieeexplore.ieee.org/document/5358673>
- OECD/European Commission. (2020). Cities in the World: A new perspective on urbanisation, OECD urban studies, OECD. Retrieved January 10, 2025, from <https://doi.org/10.1787/cd35184c-en>
- Oswald, F., Jopp, D., Rott, C., & Wahl, H. W. (2011). Is aging in place a resource for or risk to life satisfaction? *The Gerontologist*, 51(2), 238–250. <https://doi.org/10.1093/GERONT/GNQ096>
- Pan, Y., Chan, S. H. W., Xu, Y., & Yeung, K. C. (2019). Determinants of life satisfaction and self-perception of ageing among elderly people in China: An exploratory study in comparison between physical and social functioning. *Archives of Gerontology and Geriatrics*, 84, 103910. <https://doi.org/10.1016/j.archger.2019.103910>
- Pichlerová, M., Ŏnkál, D., Bartlett, A., Výbošťok, J., & Pichler, V. (2021). Variability in forest visit numbers in different regions and population segments before and during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, 18(7), 3469. <https://doi.org/10.3390/ijerph18073469>
- Pichlerová, M., Výbošťok, J., Ŏnkál, D., Lamatungga, K. E., Tamatam, D., Marcineková, L., & Pichler, V. (2023). Increased appreciation of forests and their restorative effects during the COVID-19 pandemic. *Ambio*, 52(3), 647–664.

- Prati, G. (2024). The relationship between rural-urban place of residence and subjective well-being is nonlinear and its substantive significance is questionable. *International Journal of Applied Positive Psychology*, 9, 27–43. <https://doi.org/10.1007/s41042-023-00117-2>
- Rehdanz, K., & Maddison, D. (2005). Climate and happiness. *Ecological Economics*, 52(1), 111–125. <https://doi.org/10.1016/j.ecolecon.2004.06.015>
- Reker, G. (2009). *A brief manual of the successful aging scale (SAS)*. Department of Psychology Trent University.
- Riva, A., Rebecchi, A., Capolongo, S., & Gola, M. (2022). Can homes affect well-being? A scoping review among housing conditions, indoor environmental quality, and mental health outcomes. *International Journal of Environmental Research and Public Health*, 19(23), 15975. <https://doi.org/10.3390/ijerp192315975>
- Rowe, J. W., & Kahn, R. L. (1997). Successful aging. *Gerontologist*, 37(4), 433–440. <https://doi.org/10.1093/geront/37.4.433>
- Sattari, Z., Weitkamp, G., & Meijering, L. (2023). What happens behind doors? Exploring everyday indoor activities when ageing in place. *Journal of Aging Studies*, 64, 101109. <https://doi.org/10.1016/j.jagi.2023.101109>
- Satterthwaite, D. (2007). The transition to a predominantly urban world and its underpinnings. <http://www.iied.org/pubs/pdfs/10550IIED.pdf>. Accessed 25 Feb 2026.
- Shucksmith, M., Cameron, S., Merridew, T., & Pichler, F. (2009). Urban-rural differences in quality of life across the European union. *Regional Studies*, 43(10), 1275–1289. <https://doi.org/10.1080/00343400802378750>
- Sørensen, J. F. L. (2014). Rural-urban differences in life satisfaction: Evidence from the European Union. *Regional Studies*, 48(9), 1451–1466. <https://doi.org/10.1080/00343404.2012.753142>
- Sørensen, J. F. L. (2021). The rural happiness paradox in developed countries. *Social Science Research*, 98, 102581. <https://doi.org/10.1016/j.ssresearch.2021.102581>
- StataCorp. (2021). *Stata statistical software: Release 17*. StataCorp LLC.
- Torresin, S., Ratcliffe, E., Aletta, F., Albatici, R., Babich, F., Oberman, T., & Kang, J. (2022). The actual and ideal indoor soundscape for work, relaxation and sexual activity at home: A case study during the COVID-19 lockdown in London. *Frontiers in Psychology*, 13, 1038303. <https://doi.org/10.3389/fpsyg.2022.1038303>
- UNESCO United Nations Educational, Scientific and Cultural Organization. (2003). International Standard Classification of Education, ISCED 1997. In J. H. P. Hoffmeyer-Zlotnik & C. Wolf (Eds.) *Advances in Cross-National Comparison*. Springer. Retrieved January 7, 2025, from [https://doi.org/10.1007/978-1-4419-9186-7\\_10](https://doi.org/10.1007/978-1-4419-9186-7_10)
- Valveny, N., & Gilliver, S. C. (2016). How to interpret and report the results from multivariable analyses. How to interpret and report the results from multivariable analyses. *Medical Writing*, 25(3), 37–42.
- Výboštok, J., Pichlerová, M., Lamatunga, K. E., Tamatam, D., Ōnkai, D., Halaj, D., & Pichler, V. (2024). Preferences for woodland activities and forest features as predictors of well-being after forest visits: Evidence from a nationally representative survey in Slovakia. *Ambio*, 53(5), 795–807. <https://doi.org/10.1007/s13280-024-01982-0>
- Waddell, Ch., Van Doorn, G., Power, G., & Statham, D. (2025). From successful ageing to ageing well: A narrative review. *The Gerontologist*, 65(1), gnae109. <https://doi.org/10.1093/geront/gnae109>
- Wahl, H. W., Iwarsson, S., & Oswald, F. (2012). Aging well and the environment: Toward an integrative model and research agenda for the future. *The Gerontologist*, 52(3), 306–316. <https://doi.org/10.1093/geront/gnr154>
- Wang, Y., Ma, L., Pei, J., Li, W., Zhou, Y., Dou, X., & Wang, X. (2024). The level of life space mobility among community-dwelling elderly: A systematic review and meta-analysis. *Archives of Gerontology and Geriatrics*, 117, 105278. <https://doi.org/10.1016/j.archger.2023.105278>
- Wennberg, H., Phillips, J., & Ståhl, A. (2018). How older people as pedestrians perceive the outdoor environment – Methodological issues derived from studies in two European countries. *Ageing & Society*, 38(12), 2435–2467. <https://doi.org/10.1017/S0144686X17000666>
- White, M. P., Elliott, L. R., Grellier, J., Economou, T., Bell, S., Bratman, G. N., Cirach, M., Gascon, M., Lima, M. L., Löhmus, M., Nieuwenhuijsen, M., Ojala, A., Roiko, A., Wesley Schultz, P., van den Bosch, M., & Fleming, L. E. (2021). Associations between green/blue spaces and mental health across 18 countries. *Scientific Reports*, 11, 8903. <https://doi.org/10.1038/s41598-021-87675-0>
- Whitley, E., Popham, F., & Benzeval, M. (2016). Comparison of the Rowe-Kahn model of successful aging with self-rated health and life satisfaction: The West of Scotland Twenty-07 prospective cohort study. *The Gerontologist*, 56(6), 1082–1092. <https://doi.org/10.1093/geront/gnv054>

- WHO. (2021). *Ageing and health*. Scientific Reports 2022 12:1. <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>. Accessed 7 Jan 2025.
- Williams, A. A., Spengler, J. D., Catalano, P., Allen, J. G., & Cedeno-Laurent, J. G. (2019). Building vulnerability in a changing climate: Indoor temperature exposures and health outcomes in older adults living in public housing during an extreme heat event in Cambridge, MA. *International Journal of Environmental Research and Public Health*, 16(13), 2373. <https://doi.org/10.3390/ijerph16132373>
- WMO World Meteorological Organization. (2022). *Temperatures in Europe increase more than twice global average*. <https://public.wmo.int/en/media/press-release/temperatures-europe-increase-more-than-twice-global-average>. Accessed 7 Jan 2025.
- Wolfram Research, Inc. (2021). Mathematica. Version 13.0. Wolfram Research, Inc.
- Wu, C. Y., Dodge, H. H., Reynolds, C., Barnes, L. L., Silbert, L. C., Lim, M. M., Mattek, N., Gothard, S., Kaye, J. A., & Beattie, Z. (2021). In-home mobility frequency and stability in older adults living alone with or without MCI: Introduction of new metrics. *Frontiers in Digital Health*, 3, 764510. <https://doi.org/10.3389/fgth.2021.764510>
- Wu, Y., & Cai, M. (2025). How does volunteering affect the life satisfaction of older adults? Evidence from a national survey in China. *Educational Gerontology*, 1–16. <https://doi.org/10.1080/03601277.2025.2518164>

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## Authors and Affiliations

Dhanalakshmi Tamatam<sup>1</sup>  · Magdaléna Pichlerová<sup>2</sup>  · Mayanka Ambade<sup>3</sup>  · Ibrahimu Mdala<sup>4</sup>  · Matthew North<sup>5</sup>  · Ioan Vasile Abrudan<sup>6</sup>  · Andrea Rosario Proto<sup>7</sup>  · Roman Sitko<sup>1</sup>  · Radim Boháček<sup>8</sup>  · Hassabelrasoul Abdelrahman Mohamed Saeed<sup>1</sup> · Daniel Halaj<sup>1</sup>  · Viliam Pichler<sup>1</sup> 

✉ Viliam Pichler  
pichler@is.tuzvo.sk; vilopichler@gmail.com

Dhanalakshmi Tamatam  
xtamatam@is.tuzvo.sk; drdhanalakshmi1994@gmail.com

Magdaléna Pichlerová  
pichlerova@is.tuzvo.sk

Mayanka Ambade  
mayanka@iitmandi.ac.in

Ibrahimu Mdala  
ibrahimu.mdala@medisin.uio.no

Matthew North  
MNorth@uvu.edu

Ioan Vasile Abrudan  
abrudan@unitbv.ro

Andrea Rosario Proto  
andrea.proto@unirc.it

Roman Sitko  
sitko@is.tuzvo.sk

Radim Boháček  
radim.bohacek@cerge-ci.cz

Hassabelrasoul Abdelrahman Mohamed Saeed  
xsaeed@is.tuzvo.sk

Daniel Halaj  
daniel.halaj@tuzvo.sk

- <sup>1</sup> Faculty of Forestry, Technical University in Zvolen, Zvolen, Slovakia
- <sup>2</sup> Faculty of Ecology and Environmental Sciences, Technical University in Zvolen, Zvolen, Slovakia
- <sup>3</sup> School of Humanities and Social Sciences, Indian Institute of Technology Mandi, Mandi, India
- <sup>4</sup> Faculty of Medicine, University of Oslo, Oslo, Norway
- <sup>5</sup> Department of Information Systems and Technology, Utah Valley University, Orem, UT, USA
- <sup>6</sup> Department of Silviculture, Faculty of Silviculture and Forest Engineering, Transilvania University of Brasov, Brasov, Romania
- <sup>7</sup> Department of AGRARIA, Mediterranean University of Reggio Calabria, Reggio Calabria, Italy
- <sup>8</sup> Center for Economic Research and Graduate Education – Economics Institute, Czech Academy of Sciences, Prague, Czech Republic