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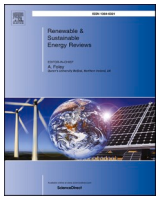

Four European typologies of older adults concerning environmental sustainability

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ABSTRACT

Transforming our societies towards a more sustainable future requires a good understanding of their citizens. This is of particular importance when considering the phenomenon of population ageing, which means that older people will constitute a significant share of society. The imperative for sustainable development arises from escalating concerns over environmental issues, necessitating tailored interventions for the heterogeneous group of older individuals. In this research, data collected using the SustainABLE-8 in Poland, North Macedonia, Romania, the Netherlands and Israel (N = 2318) were analysed in order to identify European typologies and their drivers for - and contributions to - sustainable practices. Several items of the SustainABLE-8 concerned (limiting) energy use at home as well as attitudes towards the use of sustainable energy and climate change. The study identified the existence of four major typologies, which differ in terms of their financial position, beliefs and behaviours in relation to the environment. These typologies cover 1) inactive people with limited financial resources, 2) inactive believers, 3) active and belief-driven people with limited financial resources, and 4) active and belief-driven people with financial resources. Each typology is separately discussed in terms of its specificities and ways how local governments could support their pro-environmental behaviours. The research is summarised with practical implications for industry, policymakers and environmental, social and governance strategies.

1. Introduction

In an increasingly ageing society, understanding the diverse perspectives and behaviours of older adults regarding environmental sustainability is paramount [1]. Sustainability refers to the need to ensure an adequate present while maintaining the prospects of the future. It can be understood in terms of three dimensions, namely environmental, economic and social sustainability [2,3]. This research focuses on environmental sustainability [4], and the closely related concept of sustainable development. As older people are becoming a growing segment of the population worldwide and with Europe already having the largest percentage of older people, this requires new adjustments and adaptations. There is a need to acknowledge the multifaceted landscape of older demographics and to investigate the complexities of the ageing populations [5,6] and their potential contributions to environmental sustainability efforts [7–9]. As societal demographics shift, recognising varied typologies of older adults becomes crucial for

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Nomenclature:

Abbreviations

Age-Friendly Cities and Communities Questionnaire (AFCCQ)
Hierarchical Cluster Analysis (HCA)
International Standard Classification of Education (ISCED)
Sustainable Development Goals (SDGs)
World Health Organization (WHO)

Symbols and Units

Xsub	the count of the socio-demographic and economic variable in the subgroup
Xtotal	the total count of that demographic variable in the dataset

tailored interventions and policies aimed at fostering sustainable practices among older individuals [10].

In order to shape public policies more effectively, the imperative for sustainable development has emerged as a central tenet due to escalating concerns over environmental issues spanning from social inequalities [11] and urban degradation [12] to climate change [13] and environmental deterioration [14]. Human activities continue to strain the ecological thresholds of the planet, surpassing the Earth's carrying capacity [15]. This capacity, encompassing daily choices such as dietary preferences, water and energy consumption, waste generation, transportation modes, and consumption patterns [16], is being exceeded. The complex interplay of these challenges underscores the necessity for actions, by the formulation of the Sustainable Development Goals (SDGs) [17]. Sustainable development serves as a guiding principle amidst a complex landscape where the repercussions of decisions echo across generations and geographies, inclusive of older demographics, steering us towards a future characterised by harmonious coexistence of environmental, social, and economic dimensions.

Moreover, the World Health Organization (WHO) emphasises that 15 of the 17 SDGs are pertinent to ageing, highlighting the pivotal role of cities and local stakeholders in the implementation of the SDGs [18]. According to the WHO, partnerships are needed with older people and civil society, decision-makers in governments, and across multiple sectors in the design and implementation of community programmes [19]. Moreover, a purposeful and systematic approach to addressing the needs of older persons is essential to support priorities and motivate action. This approach must meet the needs and expectations of older people as well as policymakers [19].

The convergence of the WHO's agenda for age-friendly cities, initiated nearly two decades ago [20], with global sustainability efforts clearly underscores the interdisciplinary nature of sustainability [21,22]. Longer life expectancy across the globe poses challenges for policymakers as they do not possess the experience in communicating with older people on environmental issues. Given the ageing society, including older persons in policy planning has become more prevalent. From the literature, it is known that age is associated with pro-environmental behaviours. For instance, younger persons are more concerned about the changing environment [23]. At the same time, they are less likely to engage in pro-environmental behaviours [24]. In 2024, the European Court of Human Rights ruled in the case *Verein KlimaSeniorinnen Schweiz and Others versus Switzerland* that mitigating the negative effects of climate change is a matter of human rights [25]. '*Climate grannies*', a term coined to the applicants in this case, were an association established to promote and implement effective climate protection on behalf of its members, who are more than 2000 older women, and four additional women, who complained of health problems that are exacerbated during heatwaves. In practice, many older adults do not behave in an activistic manner [25–27] nor do they consider going to court; they try to achieve sustainable goals on a much smaller scale in their daily lives.

Research by Dikken et al. [28] explored how older adults in the Netherlands perceive environmental sustainability, particularly in the context of the built environment. This study was carried out on the basis of a questionnaire, the SustainABLE-16, assessing beliefs and behaviours related to environmental sustainability. The findings revealed diverse attitudes, motivations, and actions among older individuals, underscoring the need for comprehensive assessments across different nations, including the use of renewable energy and measures to conserve energy at home [29]. While insights from the Netherlands offer valuable perspectives, they may not be universally applicable due to variations in cultural norms, socio-economic contexts and national priorities, which show the gap in the state of the art. In a later study, the SustainABLE-16 was validated using a cross-cultural approach leading to the SustainABLE-8 questionnaire [30], which took place on the basis of a large-scale dataset comprising data gathered from older people in Poland, North Macedonia, Romania, the Netherlands and Israel on drivers of sustainable practices or the absence thereof. The SustainABLE-8 still includes items on energy conservation, concerns about climate change and attitudes towards renewable energy use.

As a result of this undertaking, it is possible now to reach the objective of this exploratory research by reviewing these existing datasets with the hypothesis that it is possible to identify unique typologies among older adults concerning environmental sustainability on a European scale. The innovation of this study lies in the fact that by conducting analyses of data gathered from older people living in multiple countries in the greater European-Mediterranean region, this work will reveal for the first time – on a metalevel – if, and if so, which typologies exist among a seemingly homogeneous population of older people in the diverse set of countries in three pertinent domains of action related to sustainability. These domains are pro-environmental behaviours, financial position, and (pro-environmental) beliefs. Based on the outcomes of this study, the heterogenous set of emerging typologies can be used towards more tailored and realistic policy-making concerning ageing populations and sustainability in the future, in which differences between the older populations of targeted countries come to the fore. This is of particular importance given the increasing attention for older people in relation to the SDGs, as shown by a 2024 publication by the WHO entitled "Making older persons visible in the Sustainable Development Goals' monitoring framework and indicators" [19]. In its preface by a representative of the WHO, it is written that "*[p]eople are living longer lives and, within any country, there is no typical older person. Yet many global and national databases, reports and monitoring efforts, do not include information on older persons, or only report a wide age range, such as 60 years and over.*" [19, p. vi]. This is one of the reasons to investigate the differences that may exist between older people included in this study.

2. Review of the literature related to older adults and sustainability

2.1. Older people and the sustainable development goals

In 2015, the world reaffirmed its commitment to sustainable development by endorsing the 2030 Agenda for Sustainable Development and its 17 SDGs [19]. By 2030, one in six people around the world will be an older person. In order to understand this heterogeneous group in our societies, data collection mechanisms and methods should be explored, including age-disaggregation [19]. The WHO [19, p. xii] further stated that: "*In order to reach older people – an important, heterogeneous and growing population – and to create visibility in global and national policy and accountability mechanisms, a closer examination is needed of the kinds of data collection mechanisms and methods, and types of data collected to measure each SDG indicator relevant for older persons, including existing levels of disaggregation, analysis and dissemination.*" In addition, the WHO

[19, p.12] stated that "*[t]he SDGs are a far reaching, comprehensive set of goals and plan of action, yet there is no focus on older people, nor clear guidance on how to monitor progress for this growing global subpopulation*". The WHO also stated that the inclusion of older adults is required, which also means that all data for older adults should not be grouped into one category. Ideally, sustainable "actions should improve the lives and opportunities of people at each life stage, to develop optimally and reach their potential, as well as accumulate benefits supporting each subsequent life stage, including older age" [19, p.14].

Prior to the 2024 publication, the WHO [18] wrote that in line with the SDGs, the Global strategy and action plan on ageing and health listed five key strategic objectives on which action needs to be taken in order to improve the ability of older people to be and do what they have reason to value. Becoming age-friendly, in this sense, is critical if the SDGs and the Global Strategy are to be achieved, as was also outlined by van Hoof et al. [21], van Hoof [9] and Dabelko-Schoeny et al. [31], who described this intersection in more detail.

In previous decades, the interactions between population ageing and environmental sustainability were further narrated by Pillemer et al. [32] and Wright and Lund [33]. These works are proof that the discourse stretches back at least a quarter of a century. In the words of Pillemer and Wagenet [34, p. 6021]: "*today's [older people] must come to feel an obligation to future generations. […] we are now called to join with other generations to safeguard the world for our successors.*"

2.2. Climate change and the active engagement of older people

A new field in the scientific literature is the study of the relationship between population ageing, (environmental) sustainability, and climate change awareness [35–37], as well as emergency preparedness [31,38] and socio-environmental vulnerabilities of older persons [39]. Averting the consequences of climate change on is still achievable, but it demands immediate, collective action within a short timeframe [40]. Tackling climate change requires cooperation across generations [36]. Several well-known demographic factors are associated with pro-environmental behaviours. Age, for instance, is linked to such behaviours; research indicates that younger individuals tend to be more concerned about environmental changes compared to older individuals [41], yet they are less likely to participate in pro-environmental actions [24]. Gender also plays a significant role, with studies consistently finding that women are more environmentally conscious and more likely to engage in behaviours that support the environment [42]. Furthermore, at the societal level, nations governed by women are more inclined to support environmental policies [43]. Education is another strong predictor, as individuals with higher educational levels are more likely to engage in pro-environmental activities [24]. Older adults – at least in some countries – appear to be profoundly aware of how climate change impacts the environment. In a study by Budziszewska [44], it was found that they also declare high emotional engagement concerning this issue.

Older adults represent a significant reserve of human capital [45] essential for reducing and preventing climate change [46,47]. With increasing healthy lifespan [48] and relatively fewer family and professional responsibilities, older adults have the potential for continuous engagement in environmental activities. Their accumulated personal, professional, and cultural expertise are valuable resources that can aid environmental initiatives and solutions [49].

Additionally, older adults are known for their active civic engagement, particularly through volunteering [50], as part of active aging. Furthermore, older individuals may feel a stronger motivation to protect the future of the planet, driven by concerns of generativity and legacy [51,52], both of which encourage eco-friendly behaviours [53]. Participating in environmental activism can also meet older adults' desire for purpose and significance [46], thereby enhancing their health, well-being, and social inclusion [54,55]. Therefore, older adults have both a unique drive and potential to tackle the issue of climate change [56].

2.3. The relevance of (renewable) energy topics related to older people for sustainability

The existing literature tells us how older people can contribute to a more sustainable future, and how ageing intersects with themes like climate change, energy saving and sustainability. However, it needs to be mentioned that population ageing can have both positive and negative outcomes on sustainable development, as was outlined by research from all across the world, with a large body of knowledge coming from East Asia. A large-scale study from China by Wang et al. [57], focusing on the nexus of urbanisation, ageing and the environment, in 156 countries in total, explored ways to improve environmental quality from the perspective of an ageing population. The study identified that ageing could reduce the environmental pressures related to urbanisation, and the improvement of environmental quality is related to the higher and upper middle incomes of older people. A study by Qian et al. [58] from Hong Kong SAR focused on the connection of age-friendliness and sustainability and examined the integrated relationships between dense urban environments and needs of older people through on-street surveys. Surprisingly, the role of outdoor spaces was not found to be a planning factor relevant to all three types of sustainability.

A study conducted in Romania on adult population perceptions on climate change and sustainability goals found that age plays an important role in accepting the urgency of policies associated with sustainability and environmental protection [59]. An analysis of attitudes related to the climate change and sustainability cannot be analysed without including economic and financial issues. For Poland it was confirmed that the financial barriers to the investment in renewable energy sources investment was low among people aged 65 years and over: only 1.5 % of these households were investing in alternative energy sources, mainly due to financial constraints [60]. Other research on older people and energy use showed that groups with the highest energy needs showed a greater propensity to invest in renewable energy sources, while groups with lower energy needs face barriers related to income inequality [61,62].

Stretching even further back in time are studies on older people and fuel poverty [21], in which the implications of high costs of energy on the daily lives of older people are described after qualitative and quantitative scrutinising in studies from all over the globe. Many of these studies narrated how older people were unable to afford heating and electricity in their households, which were the unwanted side effects of a limited purchase power in times of rising energy costs and increased (environmental) taxation. Although the link with sustainability was not made in these early studies, one could argue that cost-awareness led to an austere lifestyle among the people studied. In recent years, reducing energy use in older households has once again received increased attention in research. Van Hoof [9] described how the scholarly research on climate change mitigation, environmental sustainability, the improvement of the energy efficiency of the built environment and the impacts of energy poverty all converge together. One such example is the study by Boerenfijn et al. [63], who described a number of cases from the Netherlands on how older people residing in social housing could contribute to a more sustainable future themselves through so-called energy challenges, and how renewable energy systems such as solar panels were integrated in their homes. The research showed how older people, even those residing in nursing homes, were able to reduce energy use without sacrificing comfort and quality of life, and at the same time being engaged in a meaningful activity. In the same vein, a study by Han et al. [64] from Hong Kong SAR focused on older citizens as active contributors to sustainable urban development by connecting the agenda to that of age-friendly cities and communities, identifying 15 policy factors including low-energy-consumption development as supportive factors. A large-scale study from Australia researching thermal comfort and older people in all of its facets [65], identified strategies of older South Australians to stay cool in summer and warm in winter [66, 67]. Among the driving factors were environmental consciousness

among many of the participants, as well as the cost of energy in general [67]. Based on outcomes of surveys and focus groups, various typologies of older people were distinguished, in which financial parameters as well as environmental consciousness and literacy played a role [68]. Based on the outcomes of the studies, Arakawa Martins et al. [69] used building performance simulation to further development guidelines for thermal comfort and older people, in which energy use in the built environment was an essential factor.

The analysis of energy habits from older Australians [70] and an analysis of energy consumption patterns from Japan [71] showed examples from single countries as to why and how sustainable development goals could be also achieved by older citizens. Socioeconomic conditions were found to have a greater impact on the ability of older adults to cope with energy poverty than age alone, and home heating technology is a key factor [72,73]. However, even socioeconomic conditions outweigh ageism, that is, the resilience of older citizens in dealing with energy poverty during a transition is conditioned by their material standing and welfare state robustness rather than only age based [72]. Household heating technologies, combined with economic vulnerability, can push some individuals into energy poverty, while others using alternative sources of heat can navigate through energy crises unscathed. As such a study from Portugal by Pais-Magalhães et al. [62] analysed the effect of population ageing on residential energy consumption for the 28 member states of the European Union for the period 2005–2018, employing econometric methods. First of all, this study found that different heating and cooling energy needs should be considered when designing policies. Economic and financial factors (including income inequalities) were again found to impact the study's findings. Also, the rising number of single households needs to be incorporated in the development of social and public policies at the European Union level according to the study. An Australian study by Xia et al. [74] investigated the awareness and behaviour of current older people living in retirement villages towards sustainable development through a sustainability literacy survey. The findings provide an important insight into consumer perspectives regarding the sustainable features that have a wider relevance than the Australian context. Several years before, Willis et al. [75] assessed whether older households in the United Kingdom have different behavioural responses to energy efficiency. The research indicated that the primary heating choice of older British citizens was not affected. At the same time, older person households were less inclined to adopt micro-generation technologies [75]. As well, to better understand energy consumption practices in context of climate change and sustainability behaviour, such analysis of household energy consumption should consider unconscious habits and technological structures that are not well understood in behavioural or lifestyle approaches [76].

2.4. Future research directions

As early as 2011, a research agenda was drafted for environmental sustainability in an ageing society [32], and many of the research topics that were included are still relevant today, including the intersections with ethnic, cultural and economic diversity, geographical region, and intergenerational linkages.

The existing body of literature mainly studies the interrelation between sustainability and older people from the perspective of one national context only. This is a great hindrance in the light of the globally applicable SDGs and their connection to the ageing population [19]. Each of the SDG indicators that are relevant for older persons should ideally be studied to see if there are any common denominators that are valid within countries or which extend beyond different cultures. This is one of the major limitations of the existing literature. One example of a cross-cultural approach to studying sustainability and population ageing is Dikken et al. [30], in which the SustainABLE-8 questionnaire was validated for use in countries as diverse as the Netherlands, Poland, North Macedonia, Romania and Israel. In that study it was shown that older people in the Netherlands had a broader understanding of what was important and relevant to them in connection to sustainability in daily life, than in the other countries. This led to a limited version of the original SustainABLE-16 instrument. It furthermore underscores the importance of cross-cultural approaches to studying older people and sustainability, as cultural and national contexts seem to be of great influence. Such research is of ever-growing importance as the SDGs are prescribed on the global level, without discriminating between these cultural and national differences per se.

More directions for future research were outlined by Hu [7] in a literature review on environmental sustainability and the residential environment of older people. This review came up with a research framework with evidence gaps. First of all, Hu outlined the need to develop and framework to guide the future explorations in the field in a systematic and comprehensive manner, which is concluded to be challenging due to the interdisciplinary nature of the field. Second, theories concerning the future explorations of the field should be integrated, instead of as stand-alone topics. Third, the field should be explored in a wider range of countries and regions, as ageing and sustainability are global issues.

Instead of focusing on the SDGs in total, in particular the 15 out of 17 that were deemed relevant for ageing, Dikken et al. [28] showed that there are three domains of action and study concerning older people and environmental sustainability, namely beliefs, financial position and pro-environmental behaviours. It is these three domains that should be researched in an integrated approach. Such an integrated – quantitative – approach to the study of these phenomena was not possible due to a lack of validated measurement scales and instruments. Therefore, Dikken et al. [28] developed a validated scale, the SustainABLE-16 questionnaire, for the analysis of finance- and environment-driven pro-environmental behaviours, beliefs and the financial position among older people. This scale provided a rigorous and transparent answer to the lack of a single robust scale in the field of environmental sustainability and pro-environmental behaviours. The collection of quantitative data can be used for a data-driven identification of patterns and typologies, as outlined in the Methodology section, in order to better understand which types of older people exist within the often-considered homogeneous group in the global population. By doing so, larger common denominators in beliefs, conditions and behaviours will come to the forefront, which can help inform and shape sustainable practices and policies.

3. Methodology

3.1. Datasets: settings, recruitment and participants

Datasets that were used for the study were collected in nine different cities, five countries and six language groups in 2022 and 2023, and can be found in Fig. 1: Wrocław and Kraków (Poland), Bucharest (Romania), The Hague (The Netherlands), Skopje (North Macedonia) and Tel Aviv-Jaffa, Herzliya, Kfar Saba and Jerusalem (Israel). All countries fall within the geographical reach of the WHO's European Region. Nevertheless, these countries have great geographic, socio-economic and cultural differences, which add to the diversity of the sample and could potentially result in different typologies.

The total sample covers 2318 respondents and their characteristics are presented in Table 1. As the current work concerns a secondary analysis on existing datasets, more information on the recruitment of participants and data collection can be found in Dikken et al. [30]. In order to be eligible for participation, individuals had to be aged 65 years or older. In the Netherlands, data were collected by a research bureau by post [6,29]. In Poland, data were collected by a national research company via telephone (57.3 %) and in-person interviews (42.7 %) [77]. In Romania, a local company performed face-to-face interviews collecting the data [78]. Israeli data were collected by a research bureau via an online survey [79]. In North Macedonia, a local company

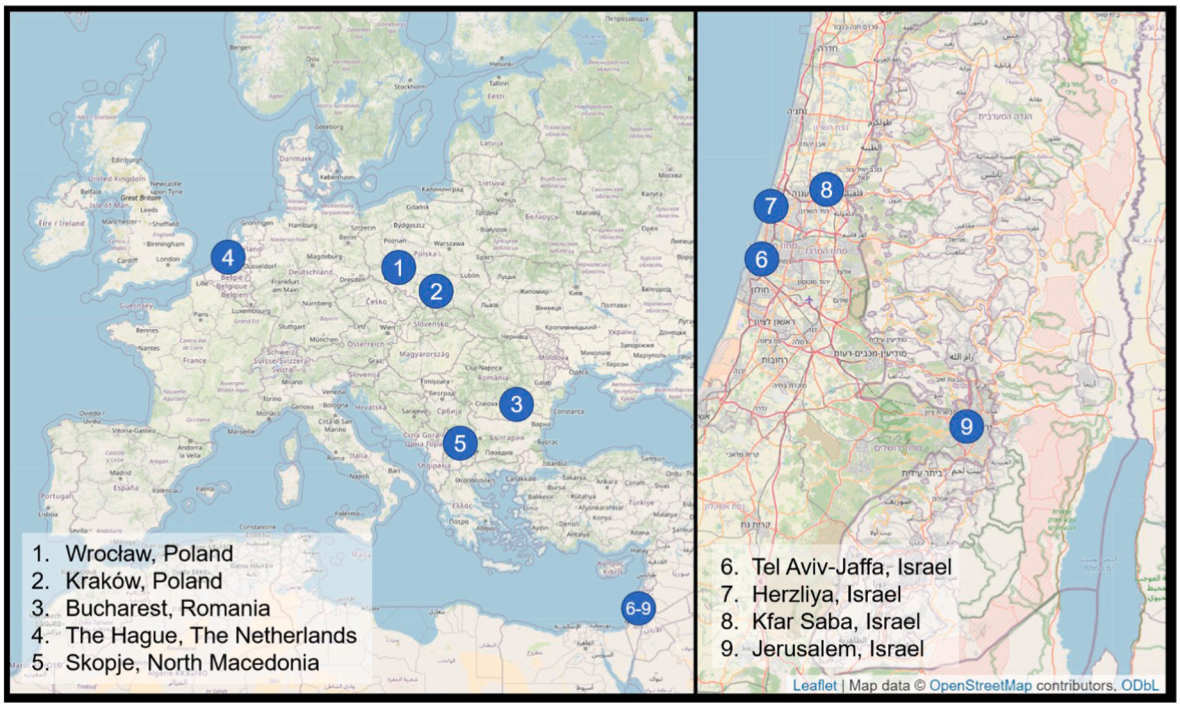

Fig. 1. Map of the cities where participants were recruited.

conducted direct interviews with Macedonian-speaking older people. A group of trained students interviewed the Albanian-speaking older adults who lived in the same municipality as the students [80]. The aim of this dual sample was to illustrate potential differences based on socio-cultural aspects of the respondents. In combination with characteristics of the other countries, this study thus transcends cultural, political and socio-economic contexts. Data collection for the cross-cultural validation took place from September 2022 to September 2023.

3.2. Measures

In addition to providing demographic data, participants answered a supplementary question about their self-assessed quality of life, rated on a scale from 1 (very poor) to 10 (very high), the results of which can be found in Table 1. Thereafter, the SustainABLE-8 questionnaire was completed [28,30]. This is a self-assessment tool designed to evaluate older adults' beliefs, behaviours, and attitudes towards environmental sustainability [28,30]. The questionnaire evaluates three key domains: 1) Pro-environmental behaviours, 2) Financial position, and 3) Beliefs (i.e., pro-environmental beliefs). Responses are rated on a five-point Likert scale ranging from −2 (strongly disagree) to +2 (strongly agree), with higher scores indicating more favourable inclinations towards environmental sustainability (see Table 2 for item specifics). Initially, the questionnaire included 16 items, which were validated at the national level, based on the Dutch results [28]. During the process of cross-cultural validation in the greater European-Mediterranean region, a total of eight items remained statistically significant. Based on that, the shorter SustainABLE-8 questionnaire can be used for older adults' beliefs, behaviours, and attitudes towards environmental sustainability across different countries. These items relate to energy-conscious behaviours (such as turning off lighting and devices, and the unnecessary use of heating or cooling), the use of renewable energy, and the affordability of sustainable measures at home. The inclusion of these items was based on literature review, expert appraisal and the views of older persons concerning the relevance of the items for them in analysis of sustainability, as well as through further statistical testing (deletion after the data demonstrated low communalities) [28].

Moreover, participants filled out the Age-Friendly Cities and Communities Questionnaire (AFCCQ) [6,81,82], which allows us to make the connection between sustainability and the age-friendly agenda of the WHO. This questionnaire is composed of 23 items, measuring eight domains of age friendliness as defined by the WHO [15] and an additional domain of one's financial situation, which is among the core indicators for the concept of age-friendly cities [81,83,84].

3.3. Analysis

To identify European typologies of older people, cluster analysis was employed to discern distinct groups among the study participants. Cluster analysis is a useful method that groups similar objects to form clusters with internal homogeneity and external heterogeneity [85]. This has been used in relation to older people and the built environment before, such as on age-friendly cities in the Netherlands [6,29], older people and the built environment in Australia, Romania and Poland [68,78,86] or in relation to pro-environmental behaviours [87,88]. In this study, cluster analysis was conducted in two stages, aligned with recommendations by Milligan [89]. The three domains of the SustainABLE-8 (Pro-environmental behaviours, Financial position, Beliefs) served as the basis for assessing similarity among participants. First, the number of clusters was determined using agglomerative hierarchical cluster analysis (HCA), a bottom-up approach that generates a dendrogram illustrating cluster similarities or distances. Ward's method, employing squared Euclidean distance, was chosen to assess association and similarity [90]. In order to detect the number of clusters, the agglomeration schedule and dendrogram were examined. Then, to validate the number of clusters, the study sample was divided by country and HCA was repeated. Additionally, the Bonferroni test, which evaluates whether the observed differences between groups or clusters are statistically significant while controlling for the increased risk of Type I errors due to multiple testing, was done [91]. This ensures that the identified differences are not simply due to chance and are statistically meaningful. Following the identification of stable clusters via the HCA procedure, a *k*-means cluster analysis was performed for classification and interpretation. This step facilitated the final clustering and

Table 1
Demographics of participants from the Netherlands, Poland, Romania, North Macedonia, and Israel (N = 2318).

	Total (n = 2318)	Poland (n = 801)	Romania (n = 424)	The Netherlands (n = 368)	North Macedonia (Macedonian population) (n = 304)	Israel (n = 223)	North Macedonia (Albanian population) (n = 198)
Sex							
Male	945 (40.8 %)	319 (39.8 %)	166 (39.2 %)	163 (44.3 %)	120 (39.5 %)	78 (35.0 %)	99 (50.0 %)
Female	1357 (58.5 %)	482 (60.2 %)	258 (60.8 %)	189 (51.4 %)	184 (60.5 %)	145 (65.0 %)	99 (50.0 %)
Missing	16 (0.7 %)			16 (4.3 %)			
Age group							
65–69	726 (31.3 %)	228 (28.5 %)	129 (30.4 %)	86 (23.4 %)	105 (34.5 %)	95 (42.6 %)	83 (41.9 %)
70–74	691 (29.8 %)	221 (27.6 %)	115 (27.1 %)	106 (28.8 %)	115 (37.8 %)	79 (35.4 %)	55 (27.8 %)
75–79	405 (17.5 %)	128 (16.0 %)	79 (18.6 %)	72 (19.6 %)	56 (18.4 %)	40 (19.9 %)	30 (15.2 %)
80–84	256 (11.0 %)	108 (13.5 %)	52 (12.3 %)	44 (12.0 %)	24 (7.9 %)	6 (2.7 %)	22 (11.1 %)
85–89	165 (7.1 %)	84 (10.5 %)	42 (9.9 %)	24 (6.5 %)	4 (1.3 %)	3 (1.3 %)	8 (4.0 %)
90+	51 (2.0 %)	32 (4.0 %)	7 (1.7 %)	12 (3.3 %)	–	–	–
Missing	24 (1.0 %)	–	–	24 (6.5 %)	–	–	–
Educational level (according to ISCED)							
Low	400 (17.3 %)	61 (7.6 %)	64 (15.1 %)	95 (25.8 %)	22 (7.2 %)	2 (0.9 %)	156 (78.8 %)
Medium	1128 (48.7 %)	431 (53.8 %)	220 (51.9 %)	168 (45.7 %)	174 (57.2 %)	106 (47.5 %)	29 (14.6 %)
High	775 (33.4 %)	306 (38.2 %)	137 (32.3 %)	96 (26.1 %)	108 (35.5 %)	115 (51.6 %)	13 (6.6 %)
Missing	15 (1.2 %)	3 (0.4 %)	3 (0.7 %)	9 (2.4 %)	–	–	–
Years living in City, Mean (SD)	55.85 (19.42)	61.97 (13.22)	51.73 (19.80)	51.11 (24.56)	62.79 (13.07)	40.71 (23.03)	54.9 (18.55)
Type of dwelling							
Owner-occupant	1913 (82.5 %)	684 (85.4 %)	350 (82.5 %)	208 (56.5 %)	300 (98.7 %)	185 (83.0 %)	186 (93.9 %)
(Private) rent	355 (15.3 %)	7 (0.9 %)	74 (17.5 %)	152 (41.3 %)	4 (1.3 %)	38 (17.0 %)	12 (6.1 %)
Missing	8 (0.3 %)	110 (13.7 %)	–	8 (2.2 %)	–	–	–
Living together with a spouse or partner	1619 (69.8 %)	569 (71.0 %)	306 (72.2 %)	161 (43.8 %)	232 (76.3 %)	166 (74.4 %)	185(93.4 %)
Receiving care	497 (21.4 %)	150 (18.7 %)	129 (30.4 %)	81 (23.9 %)	46 (15.1 %)	64 (28.7 %)	20 (10.1 %)
Living with one or more chronic conditions	1081 (46.6 %)	483 (60.3 %)	164 (38.7 %)	134 (36.4 %)	134 (44.1 %)	73 (32.7 %)	93 (47.0 %)
Using a mobility aid	511 (22.0 %)	175 (21.8 %)	181 (42.7 %)	67 (18.2 %)	25 (8.2 %)	14 (6.3 %)	49 (24.7 %)
Self-rated quality of life (scale from 1 to 10)	6.82 (2.15)	6.66 (1.94)	6.88 (3.03)	7.78 (1.08)	5.97 (2.29)	8.00 (1.19)	5.53 (1.20)

Table 2
Cluster scores on environmental sustainability.

Domain		Cluster 1 n = 368	Cluster 2 n = 661	Cluster 3 n = 590	Cluster 4 n = 699	Cluster differences
		Mean	Mean	Mean	Mean	Sign.
Pro-environmental behaviours	True-score (scale range −6 to +6	−2.21 (–)	−0.51 (–)	2.96 (++)	3.75 (+++)	0.000
Financial position	True-score (scale range −6 to +6)	−1.94 (–)	2.29 (++)	−1.06 (–)	3.57 (+++)	0.000
Beliefs	True-score (scale range −4 to +4)	0.46 (+)	1.27 (++)	1.36 (++)	2.54 (+++)	<0.001

description of cluster dimensions based on the domains of the SustainABLE-8.

Threshold scores represent the midpoints between the mean values of two adjacent clusters. These scores are used to demarcate the points at which there is a significant transition between clusters. Cohen's *d* is a measure of effect size that quantifies the difference between two means in terms of standard deviation. It is a useful metric for understanding the practical significance of the difference between clusters. A larger Cohen's *d* indicates a more substantial difference between the clusters, suggesting greater practical significance. The magnitude of Cohen's *d* was interpreted based on conventional thresholds: a small effect for $d = 0.2$, a medium effect for $d = 0.5$, and a large effect for $d = 0.8$.

Typologies were then developed by examining the demographic characteristics and AFCCQ scores breakdown within each cluster. Typologies, in this sense, are well-established analytic tools in the social sciences [92] and are a composite measure that involves the classification of observations in terms of their attributes on multiple variables [93]. According to Collier et al. [92], typologies can be put to work in forming concepts, refining measurement, exploring dimensionality, and organising explanatory claims. To adjust for the distribution of demographic variables across different subgroups, a normalisation process was applied. Firstly, the proportion of each demographic variable within

a subgroup is calculated relative to the total count of that demographic variable in the entire dataset, expressed as percentages using the following equation:

$$\text{Normalised percentage} = \frac{\text{X sub}}{\text{X } total} * 100 \qquad \text{(Equation 1)}$$

where Xsub represents the count of the socio-demographic and economic variable in the subgroup and Xtotal represents the total count of that demographic variable in the dataset. Subsequently, these normalised percentages are summed across all subgroups to establish a 'New total', representing 100 %. Finally, the percentage of each demographic variable within a specific subgroup is corrected by dividing its normalised percentage by the 'New total' and then multiplying by 100 using the following equation:

$$\text{Corrected percentage} = \frac{\text{Normalised percentage}}{\text{New total}} * 100 \qquad \text{(Equation 2)}$$

This approach allows for a fair assessment of the demographic composition within each subgroup, accounting for the overall distribution of demographic variables across the dataset.

All analyses were carried out using SPSS version 29.0 (IBM Corp., Armonk, NY, USA).

Based on the salient characteristics of each cluster, the narratives for the sustainability typologies are developed, in order to shape a fictional character around the emerging typologies. A random name will be assigned for each typology. Where appropriate, other aspects of personal factors, pro-environmental behaviours, one's financial position and beliefs, are to be incorporated to emphasize the identity and indicate specific sustainable behaviours and attitudes.

3.4. Ethics

Prior to completing the survey, all participants were provided with information regarding the study's objectives and the estimated time required for completion, which was approximately 20 min (both for the SustainABLE-8 questionnaire and AFCCQ). Participants were assured that their responses would be treated with confidentiality and anonymity, and informed consent was obtained from each participant prior to their involvement in the study. The cross-cultural research project received approval from the Institutional Review Board of the authors' institution, and it adhered to the principles outlined in the Declaration of Helsinki. In the Netherlands, Poland, and Romania, ethical acceptability certification for research involving human subjects was collectively obtained from the director of the Ethic Committee at the National University of Political Studies and Public Administration, Associate Professor Ion Stavre, on May 23, 2022. In North Macedonia, ethical acceptability certification for research involving human subjects was acquired from the Head of Quality Assurance and Management Office at the Mother Teresa University in Skopje on January 13, 2023, with certificate number 03–29/1. Approval for research in Israel was granted on May 8, 2023, from the School of Social Work of Bar Ilan University, with the assigned number 042303.

4. Results

In Fig. 2 the dendrogram generated through the clustering process is presented. The red vertical line indicates the threshold height at which four clusters were identified. This dendrogram suggests the possibility of either three, four and possibly five meaningful groups. To validate the solution, hierarchical cluster analysis (HCA) was repeated on different sub-samples. Between countries, the solution varied between four or five clusters. The Bonferroni test, however, demonstrated all p-values to be significant for the four-cluster solution, indicating significant differences between the clusters but not all p-values were significant for the five-cluster solution. As a result, the four clusters were chosen, each being distinct from the other and exhibiting unique characteristics across the tested variables. Data concerning these clusters, including cluster scores on the SustainABLE-8, can be found in Table 2.

Fig. 3 illustrates the normal distributions of clusters, threshold scores, and effect sizes (Cohen's *d*) across the three distinct domains:

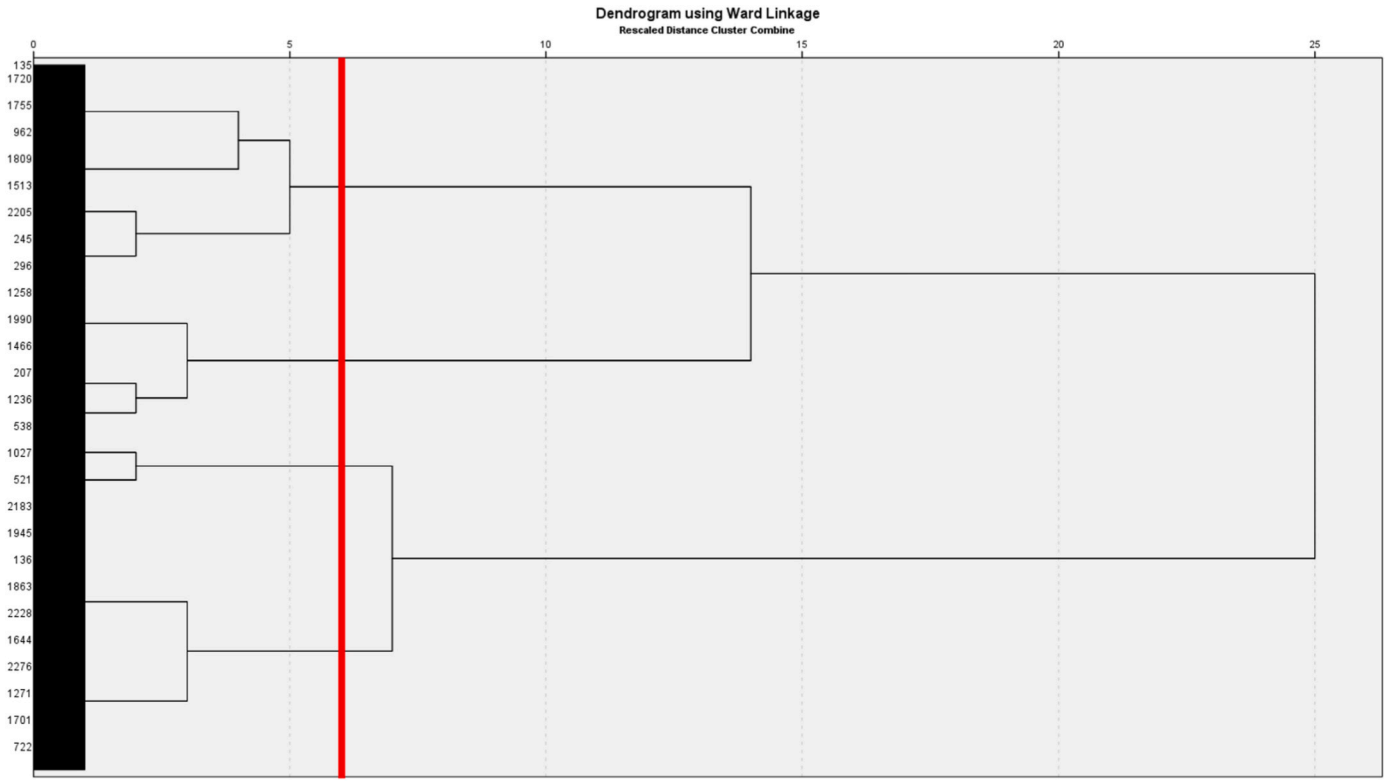

Fig. 2. Dendrogram illustrating attribution of clusters.

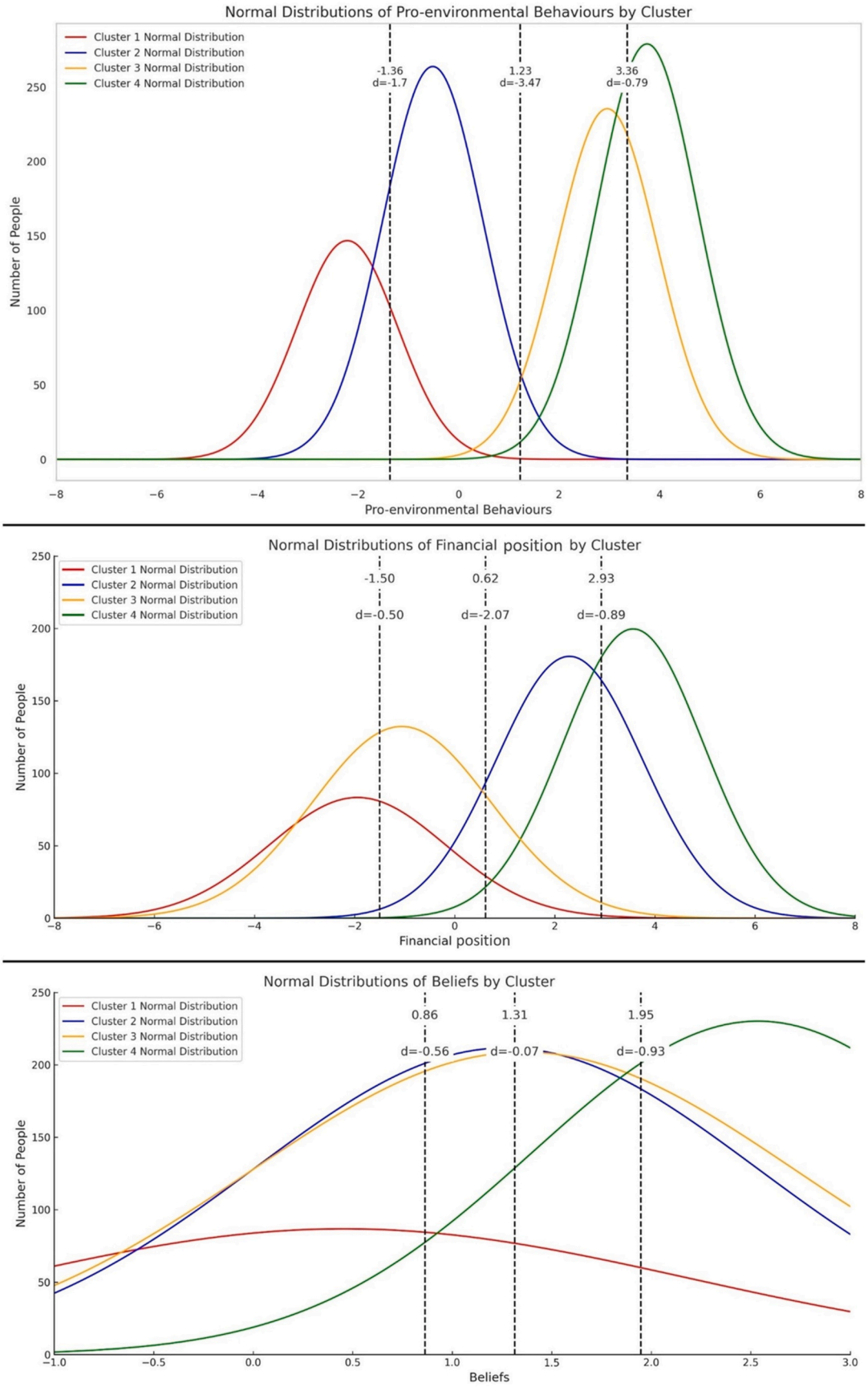

Fig. 3. Normal distributions of clusters, threshold scores, and effect sizes (Cohen's d) for Pro-environmental behaviours, Financial position, and Beliefs.

Table 3
Four sustainable typologies based on most prominent demographics (between brackets is the Relative proportion that account for the skewed distribution in the data).

	Cluster 1 n=368 Inactive people with limited financial resources	Cluster 2 n=661 Inactive believers	Cluster 3 n=590 Active and belief-driven people with limited financial resources	Cluster 4 n=699 Active and belief-driven people with financial resources
Sex female	227 (53.2%)	349 (44.2%)	374 (55.2%)	407 (50.8%)
Age				
65-69	110 (30.1%)	233 (19.1%)	157 (13.9%)	226 (18.6%)
70-74	96 (26.2%)	191 (16.5%)	188 (17.5%)	216 (18.7%)
75-79	64 (17.5%)	118 (17.4%)	99 (15.7%)	124 (18.3%)
80-84	46 (12.5%)	61 (14.2%)	85 (21.4%)	64 (14.9%)
85-89	38 (10.3%)	36 (13.0%)	42 (16.4%)	49 (17.8%)
90+	12 (3.4%)	17 (19.8%)	12 (15.1%)	10 (11.7%)
Educational level				
Low	94 (46.4%)	70 (21.7%)	143 (44.4%)	93 (26.4%)
Medium	191 (33.4%)	308 (33.8%)	316 (34.9%)	313 (31.4%)
High	79 (20.2%)	278 (44.5%)	129 (20.7%)	695 (42.2%)
Housing situation				
% owner occupant	299 (48.0%)	547 (49.7%)	447 (39.5%)	620 (63.9%)
Living situation				
% living together	281 (61.7%)	481 (54.0%)	408 (49.4%)	449 (44.1%)
Health				
% receiving care	77 (49.4%)	132 (47.8%)	123 (49.5%)	165 (53.0%)
% having a chronic disease	214 (61.9%)	278 (45.6%)	296 (53.5%)	293 (45.1%)
% using mobility aids	87 (52.3%)	102 (39.2%)	144 (53.3%)	178 (56.0%)
Quality of Life (mean, SD)	5.90 (2.16)	7.21 (1.76)	5.90 (2.38)	7.69 (1.79)
AFCCQ total	6.1 (13.91) (+)	16.9 (11.13) (++)	8.7 (12.52) (+)	21.8 (11.06) (++)
Housing mean, SD	2.3 (1.66) (+++)	2.7 (1.36) (+++)	2.1 (1.70) (+++)	2.9 (1.44) (+++)
Social participation mean, SD	1.1 (3.13) (+)	2.8 (2.74) (++)	1.6 (3.18) (+)	3.8 (3.06) (++)
Respect and social inclusion mean, SD	1.2 (2.38) (++)	1.5 (2.01) (++)	0.9 (2.11) (+)	0.9 (2.67) (+)
Civic participation and employment mean, SD	0.4 (1.87) (+)	1.5 (1.50) (++)	0.7 (1.70) (+)	2.1 (1.53) (+++)
Communication and information mean, SD	0.1 (2.15) (+)	1.3 (1.86) (++)	0.6 (1.92) (+)	1.9 (1.68) (++)
Community support and health services mean, SD	1.4 (4.46) (+)	2.8 (3.68) (++)	1.8 (3.82) (+)	4.3 (3.67) (++)
Outdoor spaces and buildings mean, SD	-0.2 (2.14) (-)	1.0 (1.89) (+)	0.4 (2.05) (+)	1.4 (1.94) (++)
Transportation mean, SD	0.7 (2.26) (+)	1.8 (1.72) (++)	1.2 (2.08) (++)	2.3 (1.74) (+++)
Financial situation mean, SD	-0.7 (2.32) (-)	1.5 (1.67) (++)	-0.5 (2.29) (-)	2.2 (1.58) (+++)

Between parenthesis are normalised percentages presented indicating the relative proportion of a specific characteristic within a cluster compared to the total number of observations in that cluster, adjusted for demographic differences.

Pro-environmental behaviours, Financial position, and Beliefs. In the domain of Pro-environmental behaviours, the four clusters presented mean scores ranging from −2.21 to 3.75. Cluster 1 (red) and Cluster 2 (blue) show substantial separation, with a threshold score at −1.36 and an effect size (Cohen's *d*) of −1.7. The next threshold at 1.23 separates Cluster 2 (blue) and Cluster 3 (orange), with a notably large effect size of −3.47. Finally, the threshold between Cluster 3 (orange) and Cluster 4 (green) is at 3.36, with an effect size of −0.79. For the domain of Financial position, the clusters also exhibit distinct distributions. The threshold between Cluster 1 (red) and Cluster 3 (orange) is at −1.50, with an effect size of −0.50. The separation between Cluster 3 (orange) and Cluster 2 (blue) is marked at 0.62, with a considerable effect size of −2.07. The final threshold at 2.93 distinguishes Cluster 2 (blue) from Cluster 4 (green), with an effect size of −0.89. Note that threshold scores and Cohen's *d* are presented for the successive clusters, and therefore the order of cluster presentation is different between the two domains. This means, for example, that the difference between Clusters 1 and 2 in the domain of Financial position is even larger than between Clusters 1 and 3 as presented in Fig. 3.

Finally, clusters show less distinct patterns in the domain of Beliefs. Cluster 1 (red) and Cluster 2 (blue) are separated at a threshold score of 0.86, with a medium effect size of −0.56. The next threshold score of 1.31 differentiates Cluster 2 (blue) and Cluster 3 (orange), with a small effect size of −0.07. Lastly, the threshold score between Cluster 3 (orange) and Cluster 4 (green) is at 1.95, with a large effect size of −0.93.

Overall, these results demonstrate clear distinctions between the clusters across the three domains, with significant threshold scores and varying effect sizes indicating the degree of difference between the clusters. These findings provide valuable insights into the clustering of Pro-environmental behaviours, Financial position, and Beliefs within the studied population.

4.1. From clusters to typologies

Based on cluster analysis, four typologies were defined by examining the demographic characteristics and AFCCQ scores breakdown within each cluster, as is shown in Table 3. The clusters can be defined using three main dimensions: Pro-environmental behaviours, Financial position, and Beliefs. Cluster 1 is a group of older people who are characterised by being in a bad economic situation, only to a small degree are they interested in the manifestation of their (pro-environmental) beliefs and their day-to-day activities are not pro-environmental. In the remainder of this work this group is called inactive people with limited financial resources. This group is the smallest from all clusters

Table 4
Narratives of the four typologies, including the context, Pro-environmental behaviours, one's Financial position, and Beliefs.

	Inactive people with limited financial resources	Inactive believers	Active and belief-driven people with limited financial resources	Active and belief-driven people with financial resources
Context	Maria and Vasile, both in their mid-70s, reside in a modest neighbourhood in Bucharest, Romania. Their humble apartment, reflecting years of frugality and hard work, is nestled amidst the bustling streets of the city.	Sarah and David, a retired couple in their early-70s, reside in a modest neighbourhood in Jerusalem, Israel. Their comfortable apartment reflects years of hard work and a commitment to practicality rather than luxury.	Ana and Stefan, a couple in their late 60s, reside in a modest apartment in Skopje, North Macedonia. Their home, though simple, is filled with warmth and reflects their dedication to sustainable living practices.	Zofia and Johannes, a couple in their early 70s, reside in a spacious and well-appointed home in the Netherlands. Their comfortable lifestyle reflects their financial stability and commitment to living in harmony with nature.
Pro-environmental behaviours	Maria and Vasile struggle to engage in pro-environmental behaviours due to their dire financial situation. While they may occasionally turn off lights or reduce heating to save money, they often find themselves unable to afford even the most basic eco-friendly practices. Maria and Vasile's environmental efforts are limited by their financial constraints, leaving them feeling powerless to enact meaningful change.	Sarah and David's pro-environmental behaviours are minimal, reflecting their scepticism and practical approach to life. They occasionally take small actions like turning off lights or reducing heating, but their efforts are inconsistent and not driven by strong environmental convictions.	Ana and Stefan are actively engaged in pro-environmental behaviours, reflecting their strong beliefs and commitment to sustainability. They consistently turn off lights, reduce heating, and make conscious efforts to minimise their environmental footprint in their daily lives.	Zofia and Johannes are passionate advocates for environmental sustainability, actively engaged in a wide range of pro-environmental behaviours. They meticulously reduce energy consumption, minimise waste, and invest in eco-friendly technologies to reduce their ecological footprint. Their commitment to sustainability extends beyond their personal lives, as they actively promote environmental awareness in their community.
Financial position	Living on a meagre pension, Maria and Vasile face constant financial strain. Their income barely covers essential expenses like food and medication, leaving no room for discretionary spending on eco-friendly products or sustainable living practices. They live in a state of perpetual financial precarity, unable to escape the cycle of poverty that shackles their environmental aspirations.	As retirees, Sarah and David have a stable financial situation, reflected in their ability to comfortably afford their energy bills and implement basic energy-saving measures in their home. However, they are cautious about making significant investments in eco-friendly upgrades, preferring to prioritise their finances for other expenses.	As retirees with limited financial resources, Ana and Stefan face challenges in their financial situation. Their income is modest, and they struggle to afford certain expenses, including energy bills. While they may not have the financial means to make significant investments in eco-friendly upgrades, they prioritise their limited resources to support their sustainable lifestyle choices. They find that many of these behaviours also contribute to savings on their utility bills.	As affluent retirees, Zofia and Johannes enjoy a comfortable financial position, reflected in their ability to afford luxury amenities and invest in eco-friendly upgrades for their home. They have the financial means to implement advanced energy-saving measures, such as solar panels and smart home systems, further reducing their environmental impact while saving on energy costs.
Beliefs	Maria and Vasile are deeply sceptical about the effectiveness of individual actions in addressing environmental issues. They view the concept of sustainable living with cynicism, doubting its feasibility in their own lives given their financial conditions. Despite their acknowledgment of nature's importance, they feel resigned to their fate, believing that their meagre efforts will have little impact on the broader environmental crisis.	Sarah and David hold moderate beliefs regarding environmental issues, scoring above neutral but still exhibiting scepticism. While they acknowledge the importance of environmental sustainability, they may question the effectiveness of individual actions and remain cautious about fully embracing eco-friendly lifestyles.	Ana and Stefan hold strong beliefs regarding environmental sustainability acknowledging the importance of using sustainable energy and have implemented various measures themselves to lead a more sustainable life. Despite their financial constraints, they remain optimistic about the potential for positive change and are dedicated to making a difference in their community.	Zofia and Johannes firmly believe in the importance of using sustainable energy and have actively implemented measures themselves to lead a more sustainable life. Living in the Netherlands, known for its progressive environmental policies and eco-conscious culture, further reinforces Zofia and Johannes' commitment to sustainability. Their financial freedom ensures they lack no resources to support their environmental goals, empowering them to make a meaningful impact on their community and beyond.

comprising 368 people. Cluster 2 is a cohort that is characterised by a good economic situation and also has a firm set of beliefs. However, when it comes to their daily choices they do not show signs of pro-environmental behaviours. This group is characterized as inactive believers, meaning that people have active knowledge but are passive in their actions. The size of Cluster 2 is 661 people. Cluster 3 is a group that contains people in poor economic condition. Despite this, both their beliefs and behaviours present pro-environmental characteristics. The group is named active and belief-driven people with limited financial resources. This cluster is made up of 590 people. Finally, very strong positive scores were observed in all three dimensions covering Financial position, Beliefs, and Pro-environmental behaviours in Cluster 4. This group is called active and belief-driven people with financial resources. This cohort is the largest among all clusters comprising 699 people.

Cluster 1, consisting of inactive people with limited financial resources, exhibits a higher likelihood of being in the 65–69 age group (30.1 %) compared to other age groups within this cluster. Moreover, there is a relatively higher chance of having a low educational level (46.4 %) among individuals in this cluster. In terms of housing situation, there is a higher likelihood of living together (61.7 %) within this cluster. Health indicators suggest a higher chance of reporting chronic diseases (61.9 %) among these individuals. The quality-of-life rating is comparatively lower, with a mean score of 5.90 (SD = 2.16).

Cluster 2, comprising inactive believers, demonstrates a lower chance of being female (44.2 %) compared to Clusters 1, 3 and 4. The age distribution is more evenly spread across different age groups, with a noticeable likelihood of being in the 90+ age group (19.8 %). Educational levels show relatively higher chances of having medium (33.7 %) to high (44.5 %) educational levels among individuals in this cluster. In terms of housing situation, there is a similar likelihood of being an owner-occupant compared to Cluster 1 (49.7 %), but a slightly smaller chance of living together with others (54.0 %). Health indicators suggest a relatively lower chance of receiving care (47.8 %) and reporting chronic diseases (45.6 %) compared to Cluster 1. Moreover, the

Table 5
Results of the SustainABLE-8 questionnaire.

Country	Pro-environmental behaviours −6 to +6 (mean and SD)	Financial position −6 to +6 (mean and SD)	Beliefs −4 to +4 (mean and SD)
Poland (n = 801)	0.89 (2.86) (+)	1.24 (2.55) (+)	1.95 (1.48) (++)
Romania (n = 424)	2.19 (2.78) (++)	0.83 (2.99) (+)	1.35 (1.52) (++)
The Netherlands (n = 336)	2.13 (2.53) (++)	1.35 (2.62) (+)	1.49 (1.50) (++)
North Macedonia (Macedonian population) (n = 304)	1.00 (2.52) (+)	0.20 (2.48) (+)	1.32 (1.33) (++)
North Macedonia (Albanian population) (n = 198)	1.65 (2.99) (++)	0.51 (2.87) (+)	0.97 (1.70) (+)
Israel (n = 223)	0.72 (2.71) (+)	3.01 (2.03) (+++)	1.39 (1.46) (++)

Pro-environmental behaviours and Financial position: + = 0–1.49; ++ = 1.5–2.99; +++ = 3.0–4.49; ++++ = 4.5–6.0.
Beliefs: + = 0–0.99; ++ = 1.0–1.99; +++ = 2.0–2.99; ++++ = 3.0–4.0.

Table 6
Percentage of older people per country belonging to one of the four clusters (bold represents percentages over 25 %).

	Cluster 1 Inactive people with limited financial resources	Cluster 2 Inactive believers	Cluster 3 Active and belief-driven people with limited financial resources	Cluster 4 Active and belief-driven people with financial resources
The Netherlands	33 (9.0 %)	82 (22.3 %)	**118 (32.1 %)**	**135 (36.7 %)**
Poland	165 (20.6 %)	**258 (32.2 %)**	142 (17.7 %)	**236 (29.5 %)**
Romania	54 (12.7 %)	78 (18.4 %)	**140 (33.0 %)**	**152 (35.8 %)**
North Macedonia (Macedonian population)	64 (21.1 %)	**78 (25.7 %)**	**111 (36.5 %)**	51 (16.8 %)
North Macedonia (Albanian population)	40 (20.2 %)	**50 (25.3 %)**	**60 (30.3 %)**	48 (24.2 %)
Israel	12 (5.4 %)	**115 (51.6 %)**	19 (8.5 %)	**77 (34.5 %)**

likelihood of using mobility aids is lower with 39.2 % than in the other clusters. The quality-of-life rating is notably higher, with a mean score of 7.21 (SD = 1.76).

Cluster 3, characterised as active and belief-driven people with limited financial resources, has a higher chance of being female (55.2 %) compared to the previous clusters. The age distribution in this cluster is more evenly spread. Similar to cluster one, there is a relatively higher chance of having a lower educational level (46.4 %) among individuals in this cluster. People in this cluster have lower chances of being an owner-occupant (39.5 %) compared to other clusters. Health indicators are most in line with Cluster 1. The quality-of-life rating for this cluster is similar to Cluster 1, with a mean score of 5.90 (SD = 2.38).

Cluster 4, composed of active and belief-driven people with financial resources, exhibits a balanced gender distribution (50.8 % females). The age distribution in this cluster is also evenly spread. Similar to Cluster 2, there is a notable chance of having a medium (33.4 %) or high educational level attained (42.2 %) among individuals in this cluster. A higher chance of being an owner-occupant (63.9 %) is observed compared to the other clusters, with fewer participants living together with others (44.1 %). Health indicators are not notably distinct from other clusters. The quality-of-life rating is the highest, with a mean score of 7.69 (SD = 1.79).

Some similarities have been observed in relation to respondents' opinions around the nine AFCCQ domains, as shown in Table 3. Clusters 1 and 3 demonstrate fairly positive while Clusters 2 and 4 have a good attitude towards all AFCC domains. The same pattern can be observed in relation to social participation, communication and information, and community support and health services. Similar correlation can be seen in relation to civic participation and employment with one clear difference that Cluster 4 shows highly positive association among respondents.

As previously mentioned in the characteristics, Clusters 1 and 3 are in an unfavourable financial condition and, therefore, unsurprisingly their opinions are negative in relation to the financial domain of the SustainABLE-8. Clusters 2 and 4 see their financial position as good or very good. Outdoor spaces and buildings are negatively perceived only by respondents from Cluster 1, whereas the other clusters describe this domain as fairly good or good. It is worth noting that respect and social inclusion scored higher among respondents who do not demonstrate pro-environmental behaviours. Analysing transportation, all respondents have a positive attitude towards this domain varying from fairly good to very good. The only domain that enjoys a very strong positive sentiment across all clusters is housing.

The salient characteristics of each cluster were used to develop narratives for the sustainability typologies. These fictional characters, from all over the included countries, are given in Table 4.

4.2. Typologies by country

Obtained results of the research have also been categorised based on country. The group that stands out are the Israeli, Hebrew speaking older respondents who described their financial position as very good, as seen in Table 5. They are pro-environmentally conscious; however, their day-to-day choices do not indicate the same importance of having pro-environmental attitudes. It is also the only country in which the population in Cluster 2 comprises more than 50 % of all respondents, as seen in Table 6.

The Polish, Macedonian, Romanian, and Dutch older respondents described their financial position as fairly good, which goes hand in hand with their pro-environmental beliefs. However, Polish and Macedonian respondents reported fairly good pro-environmental behaviours, while Romanians and Dutch reported good pro-environmental behaviours. The Albanian respondents stand out by less environmental awareness but at the same time they demonstrate relatively more pro-environmental actions (Table 5).

The differentiating characteristic among all countries is the cohabitation status. Only 44 % of older Dutch respondents live with a spouse or partner. In contrast, over 93 % of Albanian speaking respondents share their household with a spouse or partner. In the case of all other groups this indicator lies between 71 % and 76 %. The society declaring living with at least one chronic disease is Polish with 60 % of respondents from this country. Looking at mobility, the group relying on mobility aids to the largest extent are Romanians (43 %).

Table 6 further shows that older people of Cluster 1 are over 20 % of all older respondents in Poland and North Macedonia. Older people of the inactive Cluster 2 are most prevalent in Israel, and a representation of over 25 % in Poland and North Macedonia. Older people of Cluster 3 are mainly found in North Macedonia, Poland and the Netherlands,

whereas Cluster 4 is found in the Netherlands and Romania, as well as in Poland. Socio-economic conditions and the political climate in the respective countries may be the main cause for this different distribution across the included countries.

From the perspective of environmental sustainability, it is crucial for the predominant group to encompass individuals from Clusters 3 and 4, as they exhibit behaviours supportive of environmental causes. This situation can be observed among Macedonian (53.3 %), Albanian (54.5 %), Romanian (68.8 %), and Dutch (68.8 %) older respondents, as shown in Table 6.

5. Discussion

In the following sections, typologies are discussed, and a comparison is made with other studies. The strengths and limitations of the study are then discussed.

5.1. Reflection on the typologies

The results of the study show four different typologies of older people across the five analysed countries. Each of these typologies identified could be included in local policies aiming to secure the environmental goals in different ways. For example, the active and belief-driven people with financial resources are relatively the easiest to manage in the local development of sustainability policies, as one of the tasks for local authorities for this group could be to maintain their level of activity as it currently stands. This group is well-positioned to adopt renewable energy solutions, such as installing solar panels or supporting community-based renewable energy projects. Their financial resources and proactive attitude make them likely advocated for transitioning to sustainable energy sources, influencing others in their community to follow suit. This could be done by acknowledging the importance of such behaviour publicly, like it happens at earlier stages of the education process, where public praise strengthens and solidifies desired behaviour [94]. It should be highlighted that older adults in many aspects of everyday life might be even more sustainable than younger people. Wiernik et al. [95] confirmed in their meta-analysis of research published between 1970 and 2010 that older individuals appear to be more likely to engage with nature, avoid environmental harm, and conserve raw materials and natural resources. Another study conducted in Italy proved that age is significantly associated with pro-environmental behaviours such as sustainable food consumption, recycling, and energy saving. Older people appeared to be more eco-friendly compared with younger respondents [96], however, the financial factor matters.

In the case of active and belief-driven people with limited financial resources, public bodies should employ a more supportive approach. Despite their limited financial means, this group can be a strong supporter of renewable energy though advocating for public investment in clean energy solutions. They could also engage in collective renewable energy initiatives like community solar projects, which require lower personal financial investment but still allow participation in the green energy transition. Considering that this group of people does not use an excuse of its unfavourable economic situation to be passive in its habits prove how determined they are to act to improve their local environment. Within this group there is a significantly higher share of people who have lived through the Second World War. It is possible that while they were young, they experienced challenges of limited resources which could have an impact on their future behaviours and their ability to deal with shortages. Therefore, this group of older adults could become pro-environmental activists and role models for various generations [37]. Local authorities could create conditions for organised forms of non-governmental organisations or just support projects without the necessity of creating formalised groups. As people are more likely to change their behaviour into more pro-environmental when they are prompted to experience a high sense of power [97], financial support of bottom-up ideas and actions can be more effective.

People characterised as inactive believers are in favourable economic situation and their beliefs confirm their awareness of environmental challenges. However, they do not act to improve the environment as they could. It seems that this group should be the focal point of local authority involvement in supporting behavioural change. Encouraging this group to invest in renewable energy sources, such as home-based solar or wind energy systems, could unlock significant environmental benefits. Targeted campaigns highlighting the long-term financial benefits and the positive environmental legacy they can leave for future generations may serve as powerful motivators to shift their passive stance into active participation. As these people already have necessary foundations (stable economic status and pro-environmental awareness), stimulating pro-environmental activities among this group can bring pro-environmental benefits with relatively minimal expenditure in comparison with their disposable income. Depending on local context, there are different ways to reach this group of older persons. One alternative could be to highlight mutual benefits covering both the environment and well-being. As Bartolo et al. [98] proved in the case of younger people, pro-environmental behaviours improve social well-being and strengthen attachment to the place of living. In conclusion, pro-environmental actions directed towards older people may be more impactful as older citizens put more value on their surroundings.

Finally, in the case of inactive people with limited financial resources a lot of effort is required to promote more sustainable habits considering their financial limitations and challenges in daily life. For this group, access to affordable renewable energy solutions, such as government-subsidised solar programmes or energy efficiency initiatives, could help reduce their energy costs while improving their environmental impact. Public policy should focus on making renewable energy more accessible through financial assistance and education programmes. Moreover, creating partnerships between local authorities, non-governmental organisations and private sector actors can ensure that even those with limited financial means are not left behind in the energy transition. One of the methods to encourage pro-environmental behaviours is to enable people's connectedness to nature [99]. Therefore, it is important to prevent socio-environmental pauperisation in cities by allowing the creation of neighbourhoods with substandard living conditions in terms of quality of the environment. Integrating renewable energy initiatives with broader social programmes, such as public housing projects, can help reach this group more effectively ensuring that they too can benefit from the shift towards clean energy. Additionally, the preventive effects of environmental awareness can lessen the negative impacts of environmental pollution on older individuals' cognitive function and social engagement [100].

The typologies are in line with the international literature in regards to the investment in, and use of renewable energy sources. The lack of financial means led to a lower willingness to invest in such sources in Poland [60]. This is in line with the current findings that show that one's financial position is of paramount importance. At the same time, studies from Japan and the European Union [62] also showed that a higher energy need among older people led to a greater willingness to invest in renewable energy sources. Then again, financial restraints were a major barrier in these studies. This is in accordance with the four European-Mediterranean typologies that this study identified.

The threshold scores and Cohen's *d* values presented in Fig. 3 offer critical insights for both practitioners and policymakers in the domains of Pro-environmental behaviours, Financial position, and Beliefs. These metrics serve as valuable tools for identifying significant transitions between clusters and quantifying the magnitude of differences, thereby facilitating more targeted and effective interventions.

For Pro-environmental behaviours, the clear separations and large effect sizes between clusters highlight specific points where interventions could be most impactful. For instance, the substantial threshold between Cluster 2 and Cluster 3 indicates a significant behavioural shift. Policymakers can leverage this information to design targeted educational campaigns or incentives that address the factors

contributing to this shift, thereby promoting more sustainable behaviours at a critical juncture.

In the domain of Financial position, the thresholds and effect sizes reveal key areas of financial disparity. The large effect size between Cluster 3 and Cluster 2 suggests substantial financial differences that could be mitigated through targeted economic policies, financial literacy programs, or support services. By focusing on these specific typologies, policymakers can allocate resources more efficiently and implement programs that directly address the most significant financial challenges faced by the population.

The analysis of the domain of Beliefs shows less distinct patterns, but still provides useful insights. The medium effect size between Cluster 1 and Cluster 2 suggests that targeted communication strategies could be effective in shifting beliefs towards greater sustainability. Additionally, the large effect size between Cluster 3 and Cluster 4 indicates a critical transition point where more intensive interventions might be necessary to foster sustainable beliefs.

Overall, the identification of threshold scores and effect sizes facilitates a more strategic approach to both practice and policy. By focusing on the points of greatest change and the most significant differences, interventions can be more precisely targeted, leading to more efficient use of resources and more impactful outcomes. This approach not only enhances the effectiveness of current strategies but also provides a robust framework for developing new policies aimed at fostering sustainable behaviours, improving financial stability, and promoting sustainable beliefs. By utilising these insights, policymakers and practitioners can make informed decisions that drive meaningful progress towards sustainability and financial well-being.

When comparing all four sustainability typologies with the outcomes of the AFCCQ [6,77–80], there are a few findings worth taking into consideration by decision makers in city management processes. It appears that investments in housing are not a top priority for all four groups as they have evaluated this area as very good, although the incorporated questions pertain to accessibility and not to the level of renewable energy use, environmental performance or thermal insulation [30]. There are four categories directly linked to the financial position of the respondents. In case of social participation, communication and information, community support and health services as well as civic participation and employment, the higher the financial status of the respondents the better the overall evaluation of each of these domains [6,77–80]. Therefore, in order to improve the scores for these domains there is a need for initiatives that prevent socio-economic inequalities [6]. The area that needs most attention from public authorities is outdoor spaces and buildings [6,77–80]. This domain has been evaluated poorly by one of the typologies, and because of its nature rests largely within the spatial planning and urban design responsibilities of local governments.

5.2. Comparison with other studies

The four European typologies have many similarities with six typologies that were previously identified among older people in the city of The Hague in the Netherlands [29], which were formed based on the outcomes of a survey using the larger SustainABLE-16 Questionnaire [28]. Out of a total of 388 respondents, six unique typologies were identified through a two-step process combining hierarchical and *k*-means cluster analyses. These six typologies were 1) the staunch non-believers, 2) the finance-driven non-believers, 3) the everyday individuals, 4) belief-driven people with limited financial resources, 5) believing non-responders, 6) the affluent and engaging people [29]. Aspects of being active in terms of pro-environmental behaviours or holding indifferent beliefs, as well having the financial resources that drive personal choices are important elements in the Dutch study. The inactive believers, belief-driven people with limited financial resources, and active and belief-driven people with financial resources can be found back in both studies. Again, the choice to invest in renewable energy (solutions) is dictated mainly by the interaction between Financial position, Pro-environmental behaviours and Beliefs [29]. When these three drivers are aligned, the odds that an older person invests in renewable energy and related measures are higher [29].

Another research from Israel [101] identified three typologies based on the degree of engagement pro-environmental behaviours among 647 Israelis of various generations. In her study, Ayalon [101] pointed to the need for different methods to increase engagement in pro-environmental behaviours based on already existing levels of engagement, which is of importance in light of the present typologies.

As is relevant in the light of the identified typologies, there are many barriers to pro-environmental behaviours, including limited awareness and knowledge, higher financial costs, lack of time, or high cost and effort [102]. Apart from the method of communication with representatives of each of the typologies, the research results indicate the content that local policies concerning older adults should address. In this regard, it should be noted that there is no single direction for necessary actions. For example, in Romania, older adults are much more dependent on mobility aids than in other countries, indicating the importance of this issue in this country [78]. Analysing this area in more detail would require diagnosing whether mobility issues are problematic for older adults and whether this applies equally to mobility within households or outdoor spaces. Once properly addressed, it is possible to utilise the results regarding which mobility solutions users consider most needed in households [103] or public spaces [104,105]. In the case of homes, all identified typologies expressed very positive opinions, suggesting that actions in this area are not necessary. However, it should be noted that the vast majority of respondents (except those from the Netherlands) are property owners. Therefore, consideration should be given to whether and to what extent support should also be provided for social housing for older adults as a component of local housing policy [106], especially considering the proportion of the society in poor economic conditions. Regarding outdoor spaces, modernisation activities are particularly important in urban areas where the percentage of less affluent individuals is higher, as the non-responders with limited financial resources negatively assessed this aspect of the age-friendly city and community domains. This is corroborated by research showing that individuals in lower socio-economic status face challenges, such as access to urban green spaces [107].

The interplay between pro-environmental behaviours and the financial position of a society reveals a complex relationship influenced by various socio-economic factors. In this study almost 42 % of respondents (both inactive/active and belief-driven people with limited financial resources) assessed their financial position as negative. It has to be highlighted that while some individuals engage in environmentally friendly practices out of a genuine concern for the planet, others may adopt such behaviours due to financial constraints or economic affordability. It is in these conditions that older people choose not to invest in environmentally friendly solutions or renewable energy (systems). This may be aggravated by findings that older person households may be less inclined to adopt micro-generation technologies, as was shown in study from the United Kingdom by Willis et al. [75]. This distinction between environmental drivers further demonstrates differences between causes of pro-environmental behaviours, where motivations can range from intrinsic environmental awareness to extrinsic factors like income level and economic stability [108,109]. Pro-environmental actions resulting from challenging economic circumstances may, therefore, explain the outcomes observed among the Albanian community residing in Skopje. In such a scenario, it would be worthwhile to incorporate educational aspects into policies targeted at this community, as the persistent low pro-environmental beliefs of this community suggest that improving their economic status may adversely affect behavioural patterns and their impact on the environment, including the choice for renewable energy at home. Some of the typologies have a higher percentage of women (inactive people with limited financial resources and active and belief-driven people with limited financial resources). We know from

the literature that gender is a relevant variable, as women are more likely to be environmentally cautious and more likely to engage in pro-environmental behaviours [42]. Hence, it is possible that more gender-balanced samples would have resulted in a different typology, which is even less pro-environmental. Education is another consistent predictor of pro-environmental behaviours with people of higher levels of education being more likely to engage in such behaviours [24]. In this research, there arerelatively more people with higher levels of education among the inactive believers and the active and belief-driven people with financial resources. There seems to be an interplay between gender and income levels here, given the age-groups involved in this study, which is not entirely in line with previous research findings. Apart from gender and educational differences, there may also be differences between different generations. In a survey conducted in Finland, it was found that renewable energy meant more to older respondents, despite the higher cost, whereas younger people prioritised reliability [110]. An earlier study from the USA found the opposite, namely that younger people reported that renewable energy was a higher priority [111]. Even though more research in this field seems warranted, it may also help build the case for intergenerational approaches to energy conservation and climate action [36,37]. Many studies confirm the relationship between the household age and the risk of energy poverty [112,113]. The findings of this study allow for the formulating of policy recommendations on the European level, and which are not limited to a single country. The study adds to notions that different types of older households (like single person-households) are not homogeneous [114] and if the financial factors are the key driver for sustainable behaviours, such as investing in renewable and sustainable energy (systems), access to effective financial measures for older single households could be a solution. As Śleszyński [115] and Bouzarovski [116] underlined, it is important to include the technical condition of buildings in which older people live, as they could affect their opinions and expectations concerning pro-environmental behaviours. All across the European Union, thermal retrofitting of homes for older people is often linked to reducing income poverty [117].

5.3. Strengths and limitations

The study has successfully identified typologies of older people concerning environmental sustainability across a diverse range of countries in the greater European-Mediterranean region. Nevertheless, it is essential to recognise inherent strengths and limitations within this research, which also present opportunities for further development and exploration.

First of all, data collection in the participating countries took place with a cross-culturally validated tool, namely the SustainABLE-8, for which measurement invariance was established by Dikken et al. [30]. This means it was permitted to cluster older people based on their survey outcomes, as national borders of countries have become irrelevant in this perspective. In many studies making cross-country comparisons, the step of establishing measurement invariance is erroneously skipped. The fact that the instrument used in this study was cross-culturally validated adds to the rigour of the study. At the same time, one such limitation is the absence of Nordic countries or Romance-speaking countries from the Mediterranean region in the sample, as well as the exclusion of German-speaking countries and the British Isles. While this absence of an even more diverse set of countries from a socio-economic, linguistic and climatic perspective poses a limitation, it also highlights the potential for future research to broaden its scope by incorporating these regions, thereby enhancing the comprehensiveness and diversity of the study's findings. If new countries were to be included, it would also mean that measurement invariance had to be established first before including them in a larger database.

The current study is of relevance for policy-making at the level of the European Union. When making national policies, it is important to consider the four typologies from a national perspective, as each of the countries has its own political and socio-economic specificities. When working with the outcomes of this study, one should think and reflect critically about what the outcomes mean for the older people in a city or country. Table 6 further shows that all four typologies can be found in each of the participating countries in this study, regardless of the socio-economic position of the country. These figures also indicate the different priorities for policymakers on the national level, and which typologies are the most prevalent and need to be addressed the most (but not exclusively) in local or national policies.

On a global scale, the results of this study are limited to the greater European-Mediterranean region, and it would be of interest for future studies to broaden the scope of included countries and studied populations. This would, however, mean validating the SustainABLE-8 questionnaire for new national contexts before data collection among a group of older people takes place in these countries.

Additionally, the study acknowledges the inherent variability in climatic and socio-economic conditions across the analysed countries, which undoubtedly shape individuals' perspectives and experiences regarding environmental sustainability. For example, the contrasting climates between countries such as Israel and Poland emphasize the importance of contextualising opinions within the specific environmental contexts of each region, in line with recommendations on climate resilience and emergency-preparedness for ageing populations [118, 119] and calls for actions made to gerontologists to support energy policies that terminate the fossil fuel supply chain and stimulate renewable energy [120]. Similarly, differences in socio-economic status, including household composition and support networks, may also influence individuals' perceptions of environmental issues. While this variability presents challenges to direct cross-country comparisons, it provides valuable insights into diverse contextual factors, thereby enhancing the generalisability, reliability, and validity of the study's findings.

One potential course of error, which has been mitigated in the recruitment strategy where the stratification took place, is that we may have had biases in the sampled populations. We might have had a slight overrepresentation of engaged people who care about the topic, and fewer people from Cluster 1. This underrepresentation, however, would imply that this group may be even larger in number and thus of greater importance for policymakers than suggested by this study.

Furthermore, the study highlights variations in societal and political discourse surrounding environmental issues among older populations across different countries. While this variation poses a limitation in terms of generalisability, it offers an opportunity for future investigations to explore the underlying factors driving differences in engagement and perceived responsibility towards environmental sustainability. By incorporating measures to assess individuals' levels of interest, knowledge, and sense of responsibility regarding environmental issues, future research can provide more nuanced insights into the motivations behind pro-environmental behaviours among older people.

While the study's limitations underscore the complexity of conducting cross-country research on environmental sustainability among older populations, they also serve as catalysts for future inquiry and refinement. By addressing these limitations and leveraging the strengths within them, research can advance the understanding of the nuanced interplay between environmental attitudes, socio-economic contexts, and cultural factors among older individuals across diverse geographical regions.

6. Conclusions and practical implications

The conducted research leads to the following five key findings.

- Identification of four typologies among older adults: The study identified four distinct typologies of older people across five analysed countries, each with varying levels of engagement in Pro-

environmental behaviours, Financial position, and Beliefs. These typologies can be strategically engaged in different ways to promote sustainability at the local level, including the use of renewable energy (systems) as part of their sustainable practices.

- Active and belief-driven people with financial resources as sustainability advocates: The group of active and belief-driven people with financial resources is most likely to support and promote sustainability efforts. Their existing level of activity and engagement can be harnessed by local authorities to encourage pro-environmental behaviours in other sectors and populations.
- Impact of financial resources on pro-environmental behaviours: Financial stability plays a significant role in shaping pro-environmental behaviours among older adults. Those with limited financial resources, despite their belief in sustainability, require more supportive policies and interventions to overcome economic barriers to sustainable living.
- Challenges faced by inactive people with limited financial resources: Older adults with limited financial resources who are less responsive to pro-environmental initiatives pose a significant challenge. Promoting sustainable habits in this group requires substantial effort and time, emphasizing the need for long-term, resource-intensive interventions.
- Urban environment and socio-environmental pauperisation: The study highlighted the poor evaluation of outdoor spaces and buildings by certain groups of older adults, pointing to a need for focused urban planning and development policies that prevent socio-environmental pauperisation and enhance the quality of the urban environment for older citizens.

Improving the understanding of the socio-economic landscape of the ageing society in the greater European-Mediterranean region and older people's actions that align with SDGs at the grassroots level can enhance the precision of targeted public policies in this domain. This study shows that older people form indeed a very heterogeneous population, having different scores for each of the three dimensions of the SustainABLE-8 instrument. This research identified four European typologies concerning sustainable practices, including the use of renewable energy (systems) and energy conservation practices, which differ in terms of their financial position, beliefs and behaviours in relation to the environment. These groups can be used by policymakers when drafting new action programmes on making our societies more sustainable or when targeting older people as a specific group for their strategies and plans. The findings of this study can help policymakers understand the nuances in the heterogeneity of older people and help them identify groups that need further support or that have already commenced on a sustainable pathway. Being aware that there are no universal solutions suitable for every socio-cultural condition, public authorities should identify their local stakeholders, their beliefs and behaviours, economic context and citizens' needs in order to deliver support that would answer real demand in the local community without patronising or treating older people as a homogeneous group and helping them with 'one size fits none' approaches. The disaggregation of data into four typologies helps improve the available data quality on older people and sustainability. Future research should focus on the inclusion of older populations living in other countries, inside and outside of the European region, which have currently not been included in the research. Other research that could build on the foundations laid down in this study is qualitative research deepening the understanding of the lived experiences of older people in relation to sustainability, the concrete actions they undertake including the use of renewable energy, and the hindrances they encounter, for instance, through interviews and focus group sessions. Such studies could, in turn, help broaden the inclusion and active participation of older people in policies and programmes and the realisation of the SDGs.

Practical Implications or Industry, Policymakers and Environmental, Social and Governance strategies.

The study's findings suggest that industries should tailor their sustainability initiatives to align with the different typologies identified among older populations. For instance, businesses can leverage the further engagement of the already active and belief-driven people with financial resources by creating products and services that support and enhance their sustainable lifestyles. Additionally, industries involved in green technologies and services, including renewable and sustainable energy (systems), can develop targeted campaigns that resonate with belief-driven but financially constrained older individuals, promoting affordable and accessible options that align with their pro-environmental values. Moreover, companies in the housing and urban development sectors should prioritise creating environments that prevent socio-environmental pauperisation, particularly for financially disadvantaged groups, ensuring that products and services contribute to inclusive, sustainable urban living and the use of renewable energy sources.

For policymakers, the study highlights the need for differentiated approaches to promoting sustainability among older adults. Local governments should consider the diverse needs and capabilities of the different typologies when designing sustainability policies. For example, active and belief-driven people with financial resources could be mobilised as community leaders to champion pro-environmental behaviours. On the other hand, for those with limited financial resources, policies should focus on providing support through financial assistance, educational programmes, and community initiatives that make sustainable living more accessible. Additionally, the poor evaluation of outdoor spaces and buildings from the perspective of age-friendliness by certain groups underscores the need for urban planning policies that prioritise high-quality, accessible, and environmentally friendly public spaces.

The insights from this study offer valuable guidance for environmental, social and governance strategies, particularly in tailoring corporate social responsibility initiatives to different demographic segments. Companies with strong environmental, social and governance commitments should focus on engaging older adults in sustainability efforts by recognising the varying levels of financial stability and environmental awareness within this group. For instance, companies can design community outreach programmes that empower belief-driven individuals to take on active roles in sustainability projects, thereby fostering grassroots movements. Furthermore, by addressing the specific challenges faced by financially disadvantaged older adults, for example improving access to renewable energy, companies can enhance their social impact while contributing to environmental goals. This approach not only bolsters environmental, social and governance performance but also reinforces the company's commitment to creating long-term, sustainable value for all stakeholders.

CRediT authorship contribution statement

J. Dikken: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Validation, Writing – original draft, Writing – review & editing. **J.K. Kazak:** Funding acquisition, Investigation, Project administration, Visualization, Writing – original draft, Writing – review & editing. **D. Pavlovski:** Funding acquisition, Investigation, Project administration, Writing – review & editing. **L. Ivan:** Funding acquisition, Investigation, Project administration, Writing – review & editing. **L. Ayalon:** Investigation, Project administration, Writing – review & editing. **J.M. Perek-Białas:** Funding acquisition, Investigation, Project administration, Writing – review & editing. **J. van Hoof:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Availability of data and materials

The data and supporting files are available upon request.

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Data availability

Data will be made available on request.

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