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Population Ageing and the Environment: A Comparative Study of Nature-Concerning and Action-Requiring Outcomes

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Abstract

We study an under-explored implication of population ageing, i. e., its effect on country-level environmental outcomes and on individual-level environmental attitudes. In doing so, we propose a novel classification of country-level environmental outcomes, namely *action-requiring* and *nature-concerning*. The borderline between these two categories lies in the level of civic engagement required to fulfill them. Using panel data from a broad set of countries (1995–2018), we find that population ageing is linked to improvements in environmental outcomes that require minimal civic engagement, while it shows no clear association with outcomes that depend on active participation. Analysis of survey data (2006–2016) further suggests that living in ageing societies lowers individuals' environmental engagement, without affecting underlying environmental concern.

Keywords: ageing, environmental policy, individual attitudes, demographic change.

JEL Codes: J10, Q57, Q58, Q59, Z19

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1 Introduction

Population ageing is one of the most prominent issues globally with the proportion of those aged 65 and above growing faster than any other age group (United Nations 2024). Over this period of demographic change, climate change has also become one of the most salient matters in international and national affairs, resulting in growing pro-environmental efforts. Figure 1 shows that, globally, the Old-Age Dependency Ratio (OADR), i. e., the share of the population aged 65 and above relative to the population aged between 15 and 64 has risen from 8.50 in 1960 to 14.65 in 2020. Similarly and over this period, there has been a notable upward trend in the number of climate change policies and laws, climbing from a national average of 1.67 to 11.58.[1]

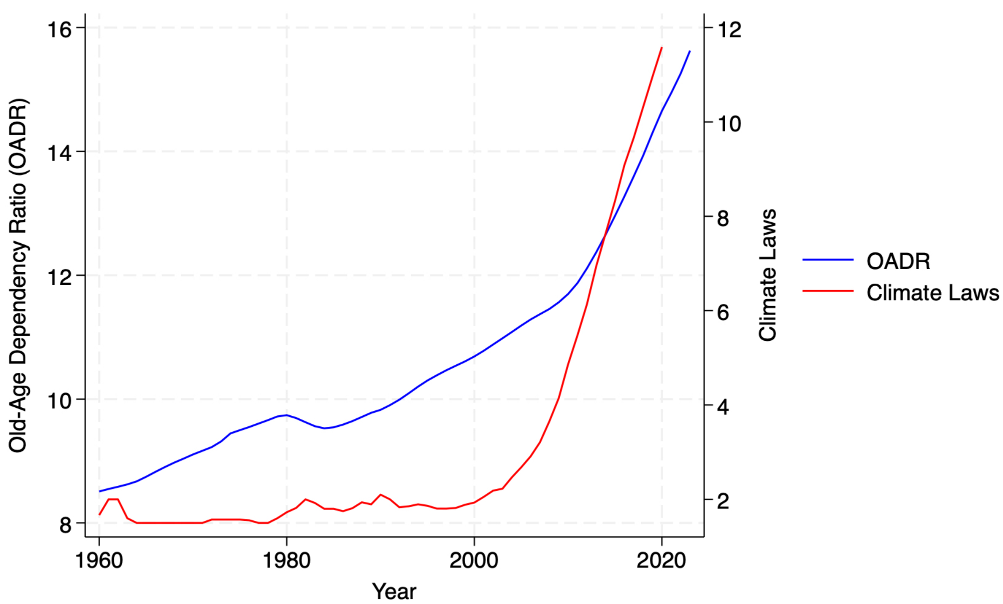

Figure 1: Evolution of the old age dependency ratio (% of working-age population) and the number of climate change laws and policies between 1960 and 2020

In this study, we examine the relationship between population ageing and two proposed categories of environmental

[1]Figure 1 is produced using data from the World Bank Development Indicators (World Bank 2024) and the The Quality of Government Environmental Indicators Dataset (Povitkina, Alvarado Pachon & Dalli 2021).

outcomes that differ in the level of civil engagement required to fulfill them. We refer to these as *action-requiring* and *nature-concerning*. Our country-level findings indicate that population ageing has an equivocal effect on action-requiring environmental outcomes and an environmentally favourable one on nature-concerning counterparts.

We argue that action-requiring environmental outcomes rely on the collective adoption of new practices and habits. At the individual level, older individuals may be less inclined to adopt recently emerging environmental behaviours, as age may hinder the formation of new habits such as recycling and sustainable energy use. As this pattern scales to the societal level, population ageing may result in lower participation, potentially weakening the uptake of action-requiring environmental measures at the aggregate level. Within this category, we examine three variables pertaining to recycling, transportation and residential activities.

In contrast, nature-concerning environmental outcomes are primarily driven by government policies and land use, rather than direct engagement from the population. The existing literature suggests that older individuals exhibit higher attachment to nature (e.g., Hughes, Rogerson, Barton & Bragg 2019). As a result, population ageing may be associated with stronger nature-concerning pro-environmental outcomes at the country level. Within this category, we consider six variables such as species protection and the share of forest land.

To examine the effect of ageing on these two proposed categories, we explore a dataset of 140 countries over the 1995 – 2018 period. Our findings indicate that ageing has a pro-environmental effect on nature-concerning environmental outcomes and an equivocal one on action-requiring counterparts.

Ensuring the validity of our results requires addressing potential endogeneity concerns, particularly those related to reverse causality. For instance, environmental outcomes such as air pollution – driven by CO2 emissions from transport and building activities – can adversely affect health outcomes. This, in turn, may reduce life expectancy and negatively affect population ageing. To mitigate this concern, we employ an instrumental variable (IV) strategy. Following Acemoglu & Restrepo (2022), we instrument population ageing using historical crude birth rates. Past fertility patterns strongly determine present population ageing, by contrast, they are unlikely to directly impact contemporary environmental outcomes. The results show that population ageing has a causal and pro-environmental effect on all variables pertaining to nature-concerning environmental outcomes and no clear effect on action-requiring outcomes.

In this paper, we also explore the relationship between population ageing of the country of residence and individual environmental attitudes using survey data from the Integrated Values Survey (IVS) between 2005 and 2016 on 68 countries.[2] We identify two distinct measures. First, *Environmental organisation membership* which estimates the participatory effort for the environment at the individual level. This measure parallels action-requiring environmental outcomes at the country level. Both rely on active engagement, which are collective for country-level action-requiring outcomes and individual for *Environmental organisation membership*. Second, *Importance of environment* which measures the subjective attachment of respondents to the environment. This measure aligns conceptually with nature-concerning environmental outcomes at the country level, as both emphasise concern for preserving the environment without requiring active participation from non-governmental actors. How does population ageing shape both country-level environmental outcomes – distinguished by their reliance on civic engagement – and individual-level environmental attitudes?

Similar to our country-level results, we uncover a differential effect of population ageing on individual-level environmental attitudes. Specifically, we show that living in a country with higher population ageing reduces environmental participatory effort captured by *Environmental organisation membership*. By contrast, we do not find a significant association between population ageing of the country of residence and subjective attachment to the environment. Instead, we show that the latter is driven by individual ageing.

The remainder of this paper is organised as follows. Section 2 reviews the related literature. Section 3 elaborates on the notions of action-requiring and nature-concerning environmental outcomes and describes the data. Section 4

[2] The Integrated Values Survey combines the datasets of the European Values Study (EVS n.d.) and the World Values Survey (Inglehart, Haerpfer, Moreno, Welzel, Kizilova, Diez-Medrano, Lagos, Norris, Ponarin, Puranen et al. 2020).

outlines our empirical strategy. Our main results appear in Section 5. Section 6 investigates the effects of population and individual ageing on environmental attitudes. Finally, Section 7 concludes. The Appendix contains additional tables and figures.

2 Literature Review

Our work lies at the intersection of two strands of the literature. The first one is concerned with the impact of population ageing on aggregate environmental outcomes, whereas the second one focuses on the effect of both population and individual ageing on individual attitudes regarding the environment.

This paper, to the best of our knowledge, is the first to evaluate the direct impact of population ageing on aggregate environmental outcomes. Studies investigating the effect of population ageing on environmental attitudes are also limited; a notable exception is the work of Wang, Hao & Liu (2021). Using data from 31 countries, the authors find a positive association between ageing, both at the country level and at the individual level, and pro-environmental behaviour.

To build on this limited economic literature, we draw on insights from other disciplines, such as anthropology and psychology. Although these fields do not directly link ageing to environmental outcomes, they provide a valuable framework to motivate our proposed mechanisms and intuitions. In doing so, our study advances the economic literature by introducing a novel approach to evaluate the effect of ageing on environmental outcomes at both the country and individual levels.

Relevant to our work and borne from the anthropological literature, Erikson (1993) developed the theory of generativity which states that during old age, individuals experience a reevaluation of life roles and develop an intrinsic need to care for future generations. Arguably, pro-environmental actions are subject to a generativity response since they involve careful and constrained use of current resources for the sake of future sustainability. Using this framework and exploring the case of environmental volunteers in Queenslands, Australia, Warburton & Gooch (2007) show that, relative to younger individuals, the cited motives of elderly respondents regarding their environmental action are related to long-term legacy for future generations and associated satisfaction in helping generations to come.

Also within this literature, Atchley (1989) proposed the continuity theory. The latter suggests that the elderly make adaptive choices and attempt to preserve their internal and external structures by adopting behaviours that are consistent with their past histories. Again, within the context of, relatively new sustainability efforts, this could translate into lower participation levels from the elderly in pro-environmental action. In aggregate, this may result in a negative effect of population ageing on action-requiring environmental outcomes.

More recently and amidst an increasing academic interest in sustainability, a literature concerned with attachment to nature has been blossoming. Connectedness, or attachment, to nature describes the subjective perception of closeness between individuals and their natural environment (Brügger, Kaiser & Roczen 2011; Nisbet, Zelenski & Murphy 2009). According to recent research, it is the strongest determinant of pro-environmental behaviour with most studies finding approximately 60 percent of common variance between the two measures (e. g., Pensini, Horn & Caltabiano 2016; Roczen, Kaiser, Bogner & Wilson 2014), even surpassing the contribution of environmental knowledge (Otto & Pensini 2017).

Closer to our research question is the relationship between age and connectedness to nature. Using face-to-face interviews on a sample of respondents in the United Kingdom, Hughes et al. (2019) find that the elderly display higher levels of attachment to nature relative to younger counterparts. These results are corroborated by a study conducted on a larger sample of participants using the Monitor of Engagement with the Natural Environment (MENE) survey.[3] It reveals considerable differences in nature attachment scores between different age groups with

[3] The objective of this survey is to measure time spent in nature and to track the different ways in which individuals interact with their natural environment.

those aged between 61 and 70 achieving the highest average score (Richardson, Hunt, Hinds, Bragg, Fido, Petronzi, Barbett, Clitherow & White 2019).

Habit-formation and related emotional processes play an important role in determining pro-environmental behaviours. Works conducted in this specific area fall primarily within the discipline of psychology. For example, Aarts, Verplanken & Van Knippenberg (1998), Smith, Haugtvedt & Petty (1994) and Staats (2003) demonstrate that deliberate behaviour is considerably driven by past behaviour. According to Ouellette & Wood (1998), there are two paths through which past behaviour influences future behaviour. First, through habit-formation which is mainly present in stable contexts, meaning that action initiation is produced through automatic processes. Second, through intention-formation which applies primarily to non-stable contexts where the effect of past behaviour is mediated by conscious reasoning. These propositions are supported by subsequent empirical research. For example, when examining a sample of college students in Hong Kong, Cheung, Chan & Wong (1999) find that the rate of paper recycling is strongly predicted by the one-month lag relating to the engagement in the same behaviour. Past bahaviour, through habit-formation, is also found to be a significant determinant of the choice of travel modes (Bamberg, Ajzen & Schmidt 2003).

This paper makes several key contributions to the literature. First, it introduces a novel classification of environmental outcomes into action-requiring and nature-concerning categories. This distinction offers a more elaborate framework and reveals the differing effects of population ageing across these two categories. Second, it extends the scope of existing research by conducting a dual-level analysis. At the country level, the study examines the relationship between population ageing and environmental outcomes using a panel dataset of 140 countries and employs an instrumental variable strategy to address potential endogeneity concerns. At the individual level, it explores the effect of population and individual ageing on environmental attitudes and behaviours using survey panel data from 68 countries. By integrating these levels of analysis, this study provides a detailed understanding of the complex relationship between population and individual ageing and environmental outcomes and attitudes.

3 Data

We explore the effect of population ageing on environmental outcomes using a baseline panel of 140 countries over the 1995 − 2018 period. Figure A3 in the Appendix shows a map of the countries sampled. The remainder of this section further explains the data employed and describes the data sources.

3.1 Population Ageing

Throughout this paper, we distinguish between *population ageing* and *individual ageing*. Population ageing refers to the varying proportion of elderly individuals within a country. In contrast, *individual ageing* refers to differences in age between individuals. This distinction enables us to assess the effects of ageing at both the societal level and the individual level in Section 6.

In this section our independent variable of interest is country-level population ageing, proxied by the Old-Age Dependency Ratio *(OADR)*. The OADR measures the number of old people – aged 65 and above – per 100 people from the working population, belonging to the 15 − 64 age bracket. The data for this variable are drawn from World Development Indicators (WDI) dataset (World Bank 2024). As shown in Table 1, the average OADR in the sample is estimated at 11.33 varying from 0.80, for the United Arab Emirates in 2010, to 34.96, for Finland in 2018.

3.2 Environmental Outcomes

This paper proposes a distinction between action-requiring and nature-concerning environmental outcomes. The former category pertains to environment-related outcomes that require active engagement from the civil population and for which large-scale behavioural changes are necessary. Recycling, for example, falls within this category due to its participatory nature. In contrast, nature-concerning environmental outcomes refer to policy measures and land use outcomes that relate to the natural environment and that do not demand substantial engagement from the civil society. These two broad categories are further detailed below.

3.2.1 Action-Requiring Environmental Outcomes

To study the effect of population ageing on action-requiring environmental outcomes, we identify the following three dependent variables: *Recycling, Transport CO2 and Building CO2*.

Recycling refers to the share of recyclable post-consumer material that is recycled in each country.[4] The data are compiled and retrieved from the Environmental Performance Index (EPI) (Wendling, Emerson, de Sherbinin, Esty & M.A. Levy 2020) and originally sourced from Chen, Bodirsky, Krueger, Mishra & Popp (2020). *Transport CO2* captures annual country-level carbon dioxide emissions from transportation as a share of total fuel combustion.[5] Given that road transport – mainly from private vehicles – accounts for the bulk of these emissions (Ritchie & Roser 2021), and that alternatives like public transport or electric vehicles require widespread behavioural shifts and individual choices (Nordfjærn, Şimşekoğlu & Rundmo 2014), this measure falls within the action-requiring category.

Building CO2 measures emissions from residential, commercial, and public buildings relative to total fuel combustion. In 2021, building operations accounted for 30 percent of energy use and 27 percent of emissions globally, with residential buildings contributing more than non-residential ones (Delmastro, De Bienassis, Goodson, Lane, Le Marois, Martinez-Gordon & Husek 2022). Since these emissions are shaped by household energy behaviour, this variable is classified as action-requiring. Data for both variables are drawn from the World Development Indicators (WDI) dataset (World Bank 2024).

[4]Recycled material encompasses glass, plastic, metal and paper.
[5]This measure excludes international marine bunkers and international aviation.

As shown in Table 1, recycling rates vary considerably in the sample from 0.86 to 66.88 percent, respectively corresponding to Chile in 1995 and in 1996 and the Republic of Korea in 2018. *Transport* and *Building CO2* also show substantial variation and have respective mean values of 32.06 and 10.42.

3.2.2 Nature-Concerning Environmental Outcomes

Nature-concerning outcomes are further decomposed into targeted policies and land use subcategories.

Targeted Policies

The subcategory of targeted policies outcomes refers to variables that measure the degree of government-induced efforts in favour of the natural environment and that do not require considerable alterations in collective behaviours from the civil population. For the baseline analysis, we focus our attention on three outcomes: *Biome protection, Species protection* and *Protected areas* for which data are available through EPI.

The biome protection indicator measures the share of each biome that lies within a protection area.[6,7] A score of 100 is assigned to countries that place at least 17 percent of each of their biome types under protection. The latter figure corresponds to the protection level prescribed by the Aichi Target 11 of the Convention on Biological Diversity that 193 countries participated in (Zafra-Calvo, Garmendia, Pascual, Palomo, Gross-Camp, Brockington, Cortes-Vazquez, Coolsaet & Burgess 2019).

Additionally, we include *Species protection* which measures the overlap between a country's terrestrial protected areas and the ranges of its plant, vertebrate and invertebrate species. A score of 100 signifies full coverage of all terrestrial species' ranges by national protected areas whilst a score of 0 implies no overlap.

Similarly, protected areas representativeness index (PARI), hereafter referred to as *Protected areas* estimates the

[6] Biomes are defined as ecological regions with distinct vegetation, climate and ecophysiology such as dry tropical forests and continental semideserts (Mucina 2019).

[7] To produce scores, EPI uses the World Database on Protected Areas (UNEP-WCMC and IUCN 2019) and measures the share of each biome within a country that is categorised as a protected area. Prevalent biomes are given smaller weights compared to more scarce ones, the proportions are aggregated into a $0 - 100$ score.

extent to which a country's ecological diversity is represented in its terrestrial protected areas. A score of 100 indicates close-to-perfect protected areas pepresentativeness. By contrast, a score of 0 indicates low representativeness (i. e., less than $5^{\text{th}}-$ percentile of values).

There is also considerable variation across the sample with regards to targeted policies, ranging from a minimum possible value of 0 to 100 for both biome and species protection indices. In 1995, three countries were assigned a score of zero regarding *Biome protection*; these were El Salvador, the United Arab Emirates and Iraq. The latter country received this score over multiple years and also obtained the lowest score when considering *Species protection* in 1995. By 2018, no country received a null score for *Species protection*. At the onset of the period studied, only Denmark scored perfectly on the latter index; by the year 2018, 8 countries were assigned the highest score, namely Belgium, Denmark, Estonia, Hungary, Poland, Slovakia, Slovenia and the United Kingdom. This ecological trend was also observed for the biome protection index; in 1995, 5 countries received a score of 100, these were Japan, Malaysia, Poland, Senegal and Zambia. By 2018, 25 countries had perfect biome protection, including Larvia, Morocco, Namibia and Slovakia.

Land Use

We consider three land use variables: *Forest land*, *Meadow land*, and *Crop land*, each measured as a share of total country area. Forests support biodiversity and are beneficial for ecosystems (Gibson, Lee, Koh, Brook, Gardner, Barlow, Peres, Bradshaw, Laurance, Lovejoy et al. 2011), while croplands are linked to environmental degradation through biodiversity loss (Molotoks, Henry, Stehfest, Doelman, Havlik, Krisztin, Alexander, Dawson & Smith 2020). Meadows and pastures have mixed effects, offering plant diversity but also contributing to environmental stress through cattle grazing. As these outcomes stem largely from land use and policy, with limited direct public involvement, they are classified as nature-concerning. Data come from Povitkina et al. (2021), based on Food and Agricultural Organization of the United Nations (2020).

There is substantial heterogeneity in the sample; the country with the smallest share of forest land is Qatar with a null value over the $2000 - 2018$ period. By contrast, Suriname was the country with the highest share which is estimated at 98.46 percent in 1995 and 1996. Djibouti has the smallest share of cropland in the sample, consistently estimated at 0.09 between 2013 and 2018, compared to a sample maximum of 68.26 for Bangladesh in both 1998 and 1999.

3.3 Controls

Using the WDI dataset, we control for *Total population*, which represents the total population expressed in millions. Larger populations may exert additional pressure on the environment through increased demand for extractive resources and intensified urbanization. Consistently with the environmental performance literature (e. g., Esty & Porter 2001; Fiorino 2011; Lau, Choong & Eng 2014), we also include the natural logarithm of Gross Domestic Product per capita (*Log of GDP per capita*) and *Institutional quality* measured per V-DEM's rule of law index (Coppedge, Gerring, Knutsen, Lindberg, Skaaning, Teorell, Altman, Bernhard, Fish, Cornell et al. 2022). Additionally, we account for climate-related covariates, namely average yearly temperatures and rainfall as well as CO2 emissions per capita using data from the WDI.

Table 1 below presents the summary statistics for a sample of 140 countries. The panel has $2,173$ observations for the variables *Transport CO2* and *Building CO2* and $3,262$ observations for all the other variables. The average total population over the period considered is 44.21 million. The mean of log of GDP per capita is 9.01 corresponding to an average annual per-capita GDP of $8,184$ in constant 2017 USD. The *Institutional quality* variable, measured on the $0 - 1$ scale, is 0.54, hence suggesting a rather even representation of institutional quality in the sample.

Table 1: Country-level analysis – Summary statistics

Variable	Description	Mean	SD	Min	Max	Count
Main independent variable						
OADR	Age dependency ratio, old (% of working-age population	11.33	7.45	0.80	34.96	3262
Action-requiring dependent variables						
Recycling	Share of recyclable post-consumer material	18.31	12.71	0.86	66.88	3262
Transport CO2	CO2 emissions from transport (% of total fuel combustion)	32.06	17.55	1.90	96.97	2173
Building CO2	CO2 emissions from residential buildings and commercial and public services (% of total fuel combustion)	10.42	7.33	0.11	39.66	2173
Nature-concerning dependent variables						
Biome protection	Terrestrial biome protection (national)	57.53	33.69	0.00	100.00	3262
Species protection	Species protection index	68.42	27.66	0.00	100.00	3262
Protected areas	Protected areas representativeness index	25.44	16.74	0.00	98.04	3262
Forest land	Forest land (% of Land area)	33.89	24.02	0.00	98.46	3262
Meadowland	Land under perm meadows and pastures (% of Land area)	22.79	18.62	0.07	83.22	3262
Cropland	Cropland (% of Land area)	18.29	15.77	0.09	68.26	3262
Controls						
Total population	Total population (in millions)	44.21	153.51	0.17	1392.73	3262
Institutional quality	Rule of law	0.54	0.30	0.03	1.00	3262
Log of GDP per capita	Natural logarithm of GDP per capita, PPP (constant 2017 international $)	9.01	1.19	6.15	11.56	3262
CO2 per cpita	CO2 emissions per capita	4.40	6.06	0.02	56.04	3262
Rainfall	Annual average rainfall	94.66	67.06	1.17	412.36	3262
Temperature	Annual average temperature	18.46	8.35	-7.43	29.37	3262

Summary: This table presents summary statistics for the main variables used in the country-level analyses. For each variable, we show the mean, standard deviation, minimum and maximum values as well as the number of observations.

4 Research Design and Identification

Our main specification relates population ageing to environmental outcomes:

$$Y_{it} = \alpha + \beta\Omega_{it} + \mathbf{X}_{it}\theta + \lambda_i + \gamma_t + \epsilon_{it} \tag{1}$$

Y_{it} represents the set of dependent variables on environmental outcomes as described in Section 2. Ω_{it} denotes the Old-Age Dependency Ratio ($OADR$) for country i at year t. This specification suggests that we are examining the contemporaneous effect of ageing on environmental outcomes. $\mathbf{X}_{it}$ is a vector of control variables, described in Table 1. We also include country fixed effects, λ_i, to capture unobserved heterogeneity at the country level like geography. γ_t is the vector of year fixed effects, capturing time-specific shocks such as the presence of a baby-boom generation across countries sampled or a shock affecting several countries in a particular year. Finally, ϵ_{it} is the country- and time-specific error term. We estimate this specification using ordinary least squares (OLS).

Although we control for many sources of unobserved heterogeneity by including time-varying control variables as well as country and year fixed effects, omitted variable bias and reverse causality could still render our regression results spurious. We are particularly preoccupied with reverse causality as environmental factors, especially pollution, are causally associated with increased deaths and deteriorated health outcomes (Fuller, Landrigan, Balakrishnan, Bathan, Bose-O'Reilly, Brauer, Caravanos, Chiles, Cohen, Corra et al. 2022). This, in turn, could reduce life expectancy, thereby affecting population ageing.

To address these plausible endogeneity concerns, we adopt an instrumental variable (IV) strategy. We instrument population ageing using historical crude birth rates following the approach adopted by Acemoglu & Restrepo (2022). Specifically, we employ the country-level birth rates 30 years prior using WDI data on crude birth rates per 1,000 people.

Intuitively, it is unlikely that historical birth rates varied across countries in anticipation of future environmental outcomes. Furthermore, it is reasonable to also assume that the IV satisfies the exclusion restriction implying that it only impacts environmental outcomes through contemporary values of the old-age dependency ratio. This is especially plausible when considering the large set of controls included in our analysis.

We employ a two-stage least squares (2SLS) estimation as our identification strategy. The dependent variable of interest (i. e., the $OADR$) is first regressed on the instrumental variable (IV) along with all other control variables. This yields the fitted values of the $OADR$ which are then used in the second stage estimation. The IV estimates are reported and further discussed in Section 5.2

5 Empirical Findings

This section outlines both the OLS and the IV regression results pertaining to the relationship between population ageing and the two categories of environmental outcomes proposed, i. e., *nature-concerning* and *action-requiring*.

5.1 Ordinary Least Squares Estimation Results

5.1.1 Action-Requiring Environmental Outcomes

Table 2 shows the OLS estimates for equation (1) pertaining to action-requiring environmental outcomes i. e., recycling rates as well as the CO2 emissions from transportation and building activities. All specifications include both year and country fixed effects in addition to the controls described in Section 3. The estimated coefficient on the *OADR* when considering recycling rates as a dependent variable, shown in column (1), is negative and significant at the 1-percent significance level. It indicates that a 1 percent increase in the share of the elderly relative to the working population, corresponding to a 1 unit increase in the *OADR*, is matched with a 0.089 percentage point decrease in recycling rates. In Finland, the *OADR* increased from 21.40 in 1995 to 34.96 in 2018, representing a rise of 13.56 units over this period. Accordingly and holding all else constant, the model predicts that this change in population ageing is associated with a 1.21 percentage point decrease in the proportion of recycled waste.

From column (2) of Table 2, the coefficient estimate on the *OADR* for *Transport CO2* is 0.202 and significant at the 5 percent significance level. This suggests that a one unit increase in our ageing measure is associated with an increase of 0.202 units of per-capita CO2 emission from transportation activities relative to total fuel combustion. Finally, the results shown in column (3) demonstrate that there is no significant association between population ageing and CO2 emissions from building activities.

Overall, population ageing appears not to foster action-requiring environmental efforts. Plausibly, this may be consistent with the presence of habit inertia where ageing countries, displaying a higher share of elderly individuals, fail to adopt novel collective behaviours to preserve their natural environment.

5.1.2 Nature-Concerning Environmental Outcomes

Table 3 shows that population ageing significantly increases pro-environmental outcomes for both targeted policies and land use variables. From column (1), (2) and (3), holding everything else constant, a 1 unit increase in the *OADR* is associated with respective changes of 1.285, 0.645 and 0.898 in *Biome protection*, *Species protection* and *Protected areas*. Furthermore, all the coefficient estimates are significant at the 1 percent significance level. Considering again the example of Finland, the model predicts that *ceteris paribus*, the change of 13.56 in the OADR over the period studied is matched with a 17.43, 8.75 and 12.18 in *Biome protection*, *Species protection* and *Protected areas*, respectively

Turning to land use outcomes, we find results that further corroborate the pro-environmental effect of population ageing on nature-concerning outcomes. From column (4) of Table 3, it is revealed that population ageing is positively associated with the share of forest land with a coefficient estimate of 0.324. From columns (5) and (6), a one unit increase in the Old-Age Dependency Ratio is associated with a 0.104 decrease in the share of meadow and pasture relative to the total land area and a 0.472 decrease in the share of cropland. These results seem to corroborate the proposition that population ageing has a pro-environmental impact on nature-concerning outcomes.

Table 2: The effect of population ageing on measures of *action-requiring* environmental outcomes - baseline regressions

	(1) Recycling	(2) Transport CO2	(3) Building CO2
OADR	-0.089***	0.202**	-0.026
	(0.011)	(0.102)	(0.062)
Total population	0.003**	-0.024***	-0.020***
	(0.001)	(0.006)	(0.004)
Institutional quality	0.249	5.514***	-1.576
	(0.178)	(1.517)	(1.118)
Log of GDP per capita	3.354***	2.088*	1.808***
	(0.129)	(1.199)	(0.600)
Rainfall	0.002***	0.024***	0.008*
	(0.001)	(0.009)	(0.005)
Temperature	0.002	0.796***	-0.621***
	(0.030)	(0.212)	(0.153)
CO2 emissions per capita	-0.017	-0.477***	-0.041
	(0.014)	(0.070)	(0.045)
Year fixed effects	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes
Observations	3262	2173	2173
Adjusted R-squared	0.998	0.930	0.876

Summary: This table presents OLS estimates of the relationship between population ageing and action-requiring environmental outcomes, namely Recycling, Transport CO2 and Building CO2. The regression results indicate the absence of a pro-environmental effect of population ageing on these specific outcomes. All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO2 emissions per capita. All regressions feature country and year fixed effects.
Notes: (i) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (ii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

Table 3: The effect of population ageing on measures of *nature-concerning* environmental outcomes - baseline regressions

	Targeted policies			Land use		
	(1) Biome protection	(2) Species protection	(3) Protected areas	(4) Forest land	(5) Meadows land	(6) Crop land
OADR	1.285***	0.645***	0.898***	0.324***	-0.104***	-0.472***
	(0.201)	(0.130)	(0.057)	(0.019)	(0.039)	(0.039)
Total population	-0.114***	-0.057***	-0.044***	0.003*	0.002	0.004**
	(0.012)	(0.006)	(0.005)	(0.002)	(0.001)	(0.002)
Institutional quality	16.119***	12.913***	2.012*	-1.487***	-0.457	0.871
	(2.397)	(1.627)	(1.090)	(0.480)	(0.538)	(0.668)
Log of GDP per capita	2.999*	2.378**	0.152	0.579**	0.591*	-0.819***
	(1.723)	(1.149)	(0.318)	(0.244)	(0.303)	(0.262)
Rainfall	0.003	0.011	-0.002	0.001	0.001	0.004*
	(0.012)	(0.008)	(0.006)	(0.003)	(0.002)	(0.002)
Temperature	0.528	0.046	-0.065	0.217***	-0.130	-0.290***
	(0.585)	(0.337)	(0.164)	(0.061)	(0.108)	(0.108)
CO2 emissions per capita	-0.696***	-0.324**	0.160***	-0.014	-0.024	0.100***
	(0.252)	(0.152)	(0.058)	(0.018)	(0.035)	(0.029)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3262	3262	3262	3262	3262	3262
Adjusted R-squared	0.890	0.935	0.949	0.996	0.989	0.983

Summary: This table presents OLS estimates of the relationship between population ageing and nature-concerning environmental outcomes which are decomposed into targeted policies and land use variables. The regression results indicate the presence of a pro-environmental effect of population ageing on these outcomes. All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO2 emissions per capita. All regressions feature country and year fixed effects. *Notes:* (i) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (ii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

5.2 Instrumental Variable Estimation Results

Since there are some gaps in the data for the variables *Transport CO2* and *Building CO2*, we characterise two distinct panels to implement our instrumental variable estimation. First, *Sample A* which is defined by all observations from the baseline sample excluding *Transport CO2* and *Building CO2*. Second, *Sample B* which is bound by observations for the variables *Transport CO2* and *Building CO2* outcomes.

The first-stage regression results are presented in columns (1) and (2) in Table 4 and in column (1) in Table 5. The coefficient estimates are -0.142 and -0.104 for *Sample A* and *Sample B*, respectively, and are significant at the 1 percent significance level, thus providing confidence in the fulfillment of the relevance condition.

The second stage results pertaining to action-requiring environmental outcomes are shown in columns (3), (4) and (5) of table 4. For *Recycling*, the IV coefficient is estimated at -0.037 and is insignificant at the 10 percent significance level, suggesting that the significance observed in the OLS specification may have been driven by endogeneity, such as omitted variable bias or reverse causality.

For Transport CO2, the IV results reveal a significant and negative effect estimated at -2.773, in sharp contrast to the OLS coefficient of 0.202, which imply a positive association. The IV results imply that population ageing is associated with a reduction in transport-related emissions. This finding may reflect shifts in mobility patterns and is consistent with the observation made by the European Environment Agency 2025 which suggest that older populations demand fewer transportation services. In the case of CO2 emissions from building operations, the IV coefficient, estimated 0.059, is not statistically significant, consistently with the OLS result. Thus, further highlighting the absence of a relationship between population ageing and CO2 emissions from building activities.

Overall, the second stage estimation results confirm the findings of the OLS estimation which suggest that, holistically, population ageing does not have a clear effect on action-requiring environmental outcomes.

The second-stage IV results for nature-concerning outcomes identify substantial pro-environmental effects of population ageing. For *Biome protection*, the IV coefficient is 3.091 and is considerably larger than the corresponding OLS estimate of 1.285, indicating that the baseline model underestimated the effect of interest. This result implies that a one-unit increase in the OADR leads to a 3.091 unit increase in the proportion of biomes under protection. Similarly, the IV coefficient is estimated at 4.256 when considering *Species protection* and is also larger in magnitude than to the OLS estimate. The IV estimate suggests that a 1 percent increase in the share of the elderly relative to the working population, i. e, a 1 unit increase in the OADR results in a 4.256 unit increase in the Species Protection Index. Finally, for *Protected areas*, the IV coefficient is significant at the 1 percent significance level and estimated at 2.644 which is also considerably larger than the OLS estimate of 0.898.

The findings of the IV estimation show that population ageing has a positive and significant effect on the share of forest land. Furthermore, the IV estimates of 0.836 is larger than that obtained under OLS which is estimated at 0.324. Similarly, the IV regression result further establish the negative effect of population ageing on the share of cropland, with an IV estimate of -1.055. This IV coefficient is also larger in magnitude than to its OLS counterpart, estimated at 0.472. Finally, for *Meadow land*, the IV coefficient is insignificant at the 10 percent significance level, in contrast to the OLS estimate, which is statistically significant. Since *Meadow land* has an ambiguous ecological role, falling between conservation and agricultural use, its lack of significance does not weaken the broader finding that population ageing has a pro-environmental effect on nature-concerning outcomes.

Overall, the results of the instrumental variable (IV) approach confirm the differential impact of population ageing on action-requiring and nature-concerning environmental outcomes. Specifically, the impact of ageing on nature-concerning environmental outcomes is unanimously pro-environmental. By contrast, there is an equivocal relationship between population ageing and the category of action-requiring environmental outcomes.

Table 4: The effect of population ageing on action-requiring environmental outcomes – First and second stage IV estimates

	First Stage		Second Stage		
	(1) Sample A	(2) Sample B	(3) Recycle	(4) Transport CO2	(5) Building CO2
Historical crude birth rates	-0.142***	-0.104***			
	(0.013)	(0.014)			
OADR (predicted)			-0.037	-2.773***	0.059
			(0.047)	(0.554)	(0.342)
Total population	-0.009***	-0.010***	0.003**	-0.049***	-0.019***
	(0.002)	(0.002)	(0.001)	(0.007)	(0.005)
Institutional quality	-0.469*	0.124	0.254	6.249***	-1.642
	(0.269)	(0.316)	(0.179)	(1.516)	(1.128)
Log of GDP per capita	0.668***	0.571**	3.361***	3.822***	1.949***
	(0.205)	(0.231)	(0.142)	(1.173)	(0.639)
Rainfall	0.002*	0.003*	0.002***	0.031***	0.008*
	(0.001)	(0.002)	(0.001)	(0.009)	(0.005)
Temperature	0.556***	0.301***	-0.027	1.621***	-0.656***
	(0.071)	(0.067)	(0.040)	(0.241)	(0.170)
CO2 emissions per capita	-0.126***	-0.058*	-0.002	-0.730***	-0.034
	(0.035)	(0.031)	(0.015)	(0.080)	(0.053)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	3231	2142	3400	2279	2279
Adjusted R-squared	0.973	0.982	0.998	0.932	0.891

Summary: This table combines the first and second-stage IV regression results for action-requiring environmental outcomes. Columns (1) and (2) present the results for the first stage showing the relationship between historical crude birth rates (instrument) and population ageing (OADR). Sample A is delimited by observations of all environmental outcomes bar Transport CO2 and Building CO2. Sample B is delimited by observations on Transport CO2 and Building CO2. Columns (3), (4) and (5) show the second stage IV estimation results of the relationship between population ageing and action-requiring environmental outcomes. It further establishes the equivocal relationship between population ageing and this category of variables. All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO2 emissions per capita. All regressions feature country and year fixed effects

Notes: (i) Crude birth rates are 30-year lags on births per 1,000 people; (ii) standard errors are clustered at the country and year levels; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

Table 5: The effect of population ageing on nature-concerning environmental outcomes – First and second stage IV estimates

	First Stage	Second Stage					
	(1) Sample A	(2) Biome Protection	(3) Species Protection	(4) Protected Areas	(5) Forest Land	(6) Meadows Land	(7) Crop Land
Historical crude birth rates	-0.142***						
	(0.013)						
OADR (predicted)		3.091***	4.256***	2.644***	0.836***	0.049	-1.055***
		(0.905)	(0.531)	(0.281)	(0.106)	(0.108)	(0.139)
Total population	-0.009***	-0.101***	-0.033***	-0.032***	0.006***	0.003**	0.000
	(0.002)	(0.016)	(0.009)	(0.006)	(0.002)	(0.001)	(0.003)
Institutional quality	-0.469*	16.641***	14.144***	2.758**	-1.307**	-0.408	0.727
	(0.269)	(2.505)	(1.767)	(1.182)	(0.513)	(0.538)	(0.702)
Log of GDP per capita	0.668***	1.802	0.181	-1.177***	0.273	0.508*	-0.531*
	(0.205)	(1.897)	(1.236)	(0.414)	(0.274)	(0.302)	(0.291)
Rainfall	0.002*	-0.001	0.004	-0.005	0.000	0.001	0.005**
	(0.001)	(0.013)	(0.009)	(0.006)	(0.003)	(0.002)	(0.002)
Temperature	0.556***	-0.444	-1.935***	-1.004***	-0.063	-0.216*	0.030
	(0.071)	(0.781)	(0.474)	(0.247)	(0.089)	(0.120)	(0.137)
CO2 emissions per capita	-0.126***	-0.601**	0.091	0.376***	0.048**	-0.009	0.030
	(0.035)	(0.273)	(0.162)	(0.085)	(0.022)	(0.039)	(0.036)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3231	3231	3231	3231	3231	3231	3231
Adjusted R-squared	0.973	0.889	0.936	0.946	0.996	0.989	0.982

Summary: This table combines the first and second-stage IV regression results for nature-concerning environmental outcomes. Columns (1) presents the results for the first stage showing the relationship between historical crude birth rates (instrument) and population ageing (OADR). Columns (2) through (7) show the second stage IV estimation results of the relationship between population ageing and nature-concerning environmental outcomes. The results further establish the presence of a pro-environmental effect of population ageing on this category of variables. All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO_2 emissions per capita. All regressions feature country and year fixed effects.

Notes: (i) Crude birth rates are 30-year lags on births per 1,000 people; (ii) standard errors are clustered at the country and year levels; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

6 Ageing and Environmental Attitudes

The findings in Section 5 demonstrate a differential effect of population ageing on environmental outcomes per the classification proposed in this study. We defined action-requiring environmental outcomes as a category of environmental variables that requires engagement from the population. By contrast, we suggested that nature-concerning environmental outcomes request relatively little participation from the population.

Since pro-environmental concerns and related efforts are a relatively new phenomenon, we conjectured that the elderly are perhaps less likely to adopt them, ultimately resulting in weaker action-requiring environmental outcomes at the country-level. We extended this reasoning and hypothesised that since individual ageing is positively associated with attachment to nature (e.g., Hughes et al. 2019; Richardson et al. 2019), then perhaps population ageing fosters nature-concerning environmental outcomes.

Overall, our results suggest that population ageing, at the country-level, has a pro-environmental effect on nature-concerning outcomes and no clear impact on action-requiring counterparts. A cursory interpretation of the aforementioned results would imply that individual ageing improves concern for the natural environment and has no effect on action-requiring environmental attitudes, in line with our intuition. However, a group-level association does not systematically identify a similar relationship at the individual-level; the latter error is known as the ecological fallacy (e.g., Robinson 1950; Selvin 1958). In this section, we account for this fallacy by explicitly investigating the effect of both population ageing of the country of residence and individual ageing on environmental attitudes.

6.1 Data and Variables

We explore the relationship between ageing, of the country of residence and at the individual level, and environmental attitudes using data from the Integrated Values Survey (IVS) covering respondants from 68 countries (listed in Table A1 shown in the Appendix) over the 2005 − 2016 period. We identify two dependent variables that are relevant for our analysis: *Importance of environment* and *Environmental organisation membership*. These align conceptually with the broad categories of action-requiring and nature-concerning environmental outcomes.

Importance of environment serves as a proxy for individual subjective attachment to the environment and is measured on a 6-point scale with higher values representing stronger attachment. Since it does not require individual active engagement, this variable is conceptually similar to nature-concerning environmental outcomes that also, per our definition, do not rely on the participation of the population.

Environmental organisation membership captures the degree of participatory effort for the environment at the individual level. For this variable, a value of 0 is assigned to respondents that are not members of an environmental organisation while 1 and 2 denote inactive and active memberships, respectively. This individual-level variable serves as a counterpart for country-level action-requiring environmental outcomes which demand active engagement and participation.

First, we examine the effect of population ageing on environmental attitudes by including the *OADR* of the country of residence as an independent variable in our regression analysis. The model incorporates the same controls used in the country-level analyses, namely *Total population*, *Institutional quality*, *Log of GDP per capita*, *Rainfall* and *Temperature*, as well as *CO2 emissions per capita*. Additionally, we include the following individual-level covariates: *Sex*, *Age*, *Marital status*, *Employment status*, *Educational level*, and subjective income level, referred to as *Income level*. Second, we investigate the relationship between individual ageing and environmental attitudes by incorporating age dummies into the regression analysis. The regression analyses also include both country fixed effects as well as time dummies capturing the survey year.

Table 6 displayed below presents the descriptive statistics for the individual-level variable used in the analysis. The average score of 4.52 for *Importance of environment* suggests a rather high attachment to the environment from respondent in the sample. By constant, the mean value for *Environmental organisation membership* is 0.15, indicating low participatory effort for the environment.

There are 124,615 respondents in the sample of which $63,973$ are female and 60,642 are male. $68,724$ respondents are married and 41,895 work full-time, retirees account for 12.7 percent of the sample with a total count of $15,785$. Most respondents, i. e., $80,317$, completed at least secondary school education and $75,333$ report having a medium subjective income level.

Table 6: Individual-level analysis – Summary statistics

Description	Mean	SD	Min	Max	Count
Importance of environment (i. e., it is important to this person looking after the environment)	4.52	1.26	1.00	6	124615
Environmental organisation membership (i. e., Active/Inactive membership of environmental organisation)	0.15	0.45	0.00	2	124615
Sex	1.51	0.50	1.00	2	124615
Age	41.03	16.28	15.00	98	124615
Marital status	2.75	2.20	1.00	6	124615
Employment status	3.37	2.18	1.00	8	124615
Educational level	4.83	2.19	1.00	8	124615
Income level	1.84	0.61	1.00	3	124615

Summary: This table presents summary statistics for the main variables used in the individual-level analyses. For each variable, we show the mean, standard deviation, minimum and maximum values as well as the number of observations.

6.2 Research design and identification

We examine the relationship between ageing and individual environmental attitudes by considering two distinct dimensions: population ageing of the country of residence and individual ageing. This dual approach enables us to differentiate between the broader contextual effects of living in an ageing society and the specific effects associated with individual ageing.

We use the following specification to study the relationship between population ageing on individual environmental attitudes:

$$Y_{jit} = \alpha_1 + \beta_1 \Omega_{jit} + \mathbf{Z}_{jit} \gamma_1 + \lambda_i + \gamma_t + \epsilon_{jit} \tag{2}$$

Y_{jit} denotes the environmental attitudes of individual j residing in country i at year t. Ω_{jit} is our population ageing variable and represents the Old-Age Dependency Ratio ($OADR$) in the country of residence i of individual j at year t . $\mathbf{Z}_{jit}$ encompasses both individual and country-level control variables, as described in Section 6.1. Finally, λ_i and γ_t are country and survey year fixed effects, respectively.

To analyse the relationship between individual ageing and environmental attitudes, we extend the specification to include age dummies:

$$Y_{jit} = \alpha_2 + \beta_2 \Omega_{jit} + \sum_{a=2}^{A} \eta_a D_{ja} + \mathbf{Q}_{jit} \gamma + \lambda_i + \gamma_t + \epsilon_{jit} \tag{3}$$

D_{ja} represents age group dummies and captures whether individual j belongs to age group a. The age groups used in the analysis are: $25-34$, $35-44$, $45-54$, $55-64$ and *Above* 65; our reference category is $15-24$. We replace the continuous age variable to study non-linear effects of age on environmental attitudes. Consequently, the vector of controls, $\mathbf{Q}_{jit}$, is the same as $\mathbf{Z}_{jit}$ except that it excludes the variable *age*.

6.3 Empirical findings

This subsection presents the findings on the relationship between – population and individual – ageing and environmental attitudes.

6.4 Population Ageing

Table 7 reports estimates of the effect of population ageing of the country of residence on the variables *Importance of environment* and *Environmental organisation membership*. Columns (1) and (2) only include the OADR of the country of residence, country-level controls as well as country and year fixed effects. In the subsequent columns, we add the individual-level covariates described above.

When considering *Importance of environment* as a dependent variable, the coefficient estimates on the *OADR*, displayed in columns (1) and (3), are insignificant. This implies that population ageing in the country of residence has no effect on subjective attachment to the environment. Of interest, as shown in column (3), the coefficient estimate on *age* is positive and significant at the 1 percent significance level. The estimate indicates that each additional year of age is associated with a 0.007 unit increase in the variable *Importance of environment*.

Columns (2) and (4) of Table 7 shows that coefficient on the *OADR* is negative and significant at the 1 percent significance level when evaluating *Environmental organisation membership*. This implies that living in a country with higher population ageing decreases individual participatory effort for the environment. In particular, from column (4), the point estimate shows that a 1 unit increase in the *OADR* of the country of residence is associated with a 0.028 unit decrease in the environmental organisation membership index.

Table A2 in the Appendix shows the results with displayed coefficient estimates for the country-level controls.

Table 7: The effect of population ageing of the country of residence on attitudes related to subjective attachment to the environment and participatory effort for the environment

	(1) Importance of environment	(2) Environmental organisation membership	(3) Importance of environment	(4) Environmental organisation membership
OADR	-0.036	-0.027***	-0.042	-0.028***
	(0.027)	(0.007)	(0.028)	(0.007)
Sex			0.060***	-0.012***
			(0.012)	(0.004)
Age			0.007***	0.000**
			(0.001)	(0.000)
Marital status			-0.012***	-0.000
			(0.003)	(0.001)
Employment status			0.005*	-0.004***
			(0.003)	(0.001)
Educational level			0.031***	0.011***
			(0.003)	(0.001)
Income level			-0.012	0.020***
			(0.015)	(0.005)
Country fixed effects	Yes	Yes	Yes	Yes
Survey year fixed effects	Yes	Yes	Yes	Yes
Observations	124615	124615	124615	124615
Adjusted R-squared	0.101	0.096	0.110	0.101

Summary: This table presents the OLS estimates of the relationship between country-level population ageing and individual environmental attitudes. It shows that population ageing of the country of residence has no significant effect on subjective attachment to the environment (*Importance of environment)* and has a negative effect on participatory effort for the environment (*Environmental organisation membership*). All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO2 emissions per capita. Individual-level controls, sex, age, marital status, employment status, educational level and income level, are only included in the specifications shown in columns (3) and (4). All regressions feature country and survey year fixed effects. *Notes:* (i) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (ii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

6.5 Individual Ageing

The estimated coefficients on the different age groups shown in column (1) of Table 8 indicate that individual ageing is an important determinant of subjective attachment to the environment. The effect strengthens with age, with all age groups displaying a positive and significant association compared to the reference group $(15-24)$. The coefficient increases from 0.046 for individuals aged $25-34$ to 0.121 for those aged $35-44$, 0.183 for the $45-54$ age group, and 0.270 for those aged $55-64$. The largest effect is observed for individuals aged *Above* 65, with a coefficient of 0.349, suggesting a stronger attachment to the environment among older respondents. By contrast, column (2) does not reveal clear differences in *Environmental organisation membership* across the age groups considered.

It is plausible that the aforementioned results are driven by cohort effects, hence resulting in generation-specific differences. This could be due to the presence of formative large-scale experiences such as wars, school curricula or specific policies. To untangle those effects from individual age, we include cohort fixed effects in the analysis and report the results in columns (3) and (4) of Table 8.

Column (3) of Table 8 shows that, overall, accounting for cohort fixed effects reduces the estimated coefficients on the age groups for the variable *Importance of environment.* The only exception is the $25-34$ group, where the coefficient increases slightly from 0.046 to 0.047. The highest coefficient is observed for the $55-64$ group at 0.167, followed by the *Above* 65 age group at 0.164. The coefficients for the other age groups also decline but remain substantial, with the estimate for $35-44$ decreasing to 0.097 and for $45-54$ to 0.131. These regression results further establish the findings that individual ageing is associated with stronger subjective attachment to the environment.

In contrast, the results for *Environmental organisation membership* shown in column (3) remain largely unchanged. The coefficient estimates for all age groups are close to zero and statistically insignificant, providing no evidence that individual ageing increases participatory effort for the environment. Instead, the negative and significant coefficient on the *OADR* suggests that the decline in *Environmental organisation membership* is driven by population ageing in the country of residence.

In this section, we documented a distinct relationship between ageing and environmental attitudes. Our results showed that subjective importance of the environment (i. e., *Importance of environment*) is positively driven by individual ageing, and not by population ageing of the country of residence. By contrast, we found that individual ageing has no statistically significant effect on participatory effort for the environment, proxied by *Environmental organisation membership*, and that the latter is determined by population ageing in the country of residence. Our results suggested that living in a country with higher population ageing reduces participatory effort for the environment. Table A3 in the Appendix reports the results with displayed coefficients for country-level controls.

Table 8: The effect of population ageing of the country of residence and individual ageing on attitudes related to subjective attachment to the environment and participatory effort for the environment

	(1) Importance of environment	(2) Environmental organisation membership	(3) Importance of environment	(4) Environmental organisation membership
OADR	-0.042	-0.029***	-0.040	-0.028***
	(0.028)	(0.007)	(0.028)	(0.007)
Respondents' age groups				
25-34	0.046**	-0.002	0.047**	-0.000
	(0.021)	(0.006)	(0.021)	(0.007)
35-44	0.121***	0.007	0.097***	0.009
	(0.020)	(0.007)	(0.029)	(0.010)
45-54	0.183***	0.018**	0.131***	0.014
	(0.024)	(0.007)	(0.037)	(0.012)
55-64	0.270***	0.013	0.167***	0.002
	(0.030)	(0.008)	(0.045)	(0.014)
Above 65	0.349***	0.014	0.164***	-0.007
	(0.032)	(0.010)	(0.052)	(0.018)
Country FE	Yes	Yes	Yes	Yes
Survey year FE	Yes	Yes	Yes	Yes
Cohort FE	No	No	Yes	Yes
Observations	124615	124615	124615	124615
Adjusted R-squared	0.110	0.101	0.111	0.101

Summary: This table presents the OLS estimates of the relationship between country-level population ageing as well as individual ageing and individual attitudes towards the environment.. It shows that population ageing of the country of residence has no significant effect on subjective attachment to the environment (*Importance of environment*) and has a negative effect on participatory effort for the environment (*Environmental organisation membership*). Furthermore, the regression results show significant differences in subjective attachment to the environment across age groups. All specifications include country-level controls: total population, institutional quality, the natural logarithm of GDP per capita, average yearly rainfall and temperature, and CO2 emissions per capita. They also include individual-level controls: sex, age, marital status, employment status, educational level and income level. Specifications presented in column (3) and (4) also include cohort fixed effects. All regressions feature country and survey year fixed effects.

Notes: (i) Omitted age category is *Below* 24. (ii) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (iii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iv) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

7 Conclusion

In this paper, we explore the association between population ageing and the environment by proposing a novel classification of environmental outcomes which depends on the involvement of the population. We identify two categories of environmental outcomes, namely action-requiring and nature-concerning, where the former is defined as requiring considerably stronger engagement from the population relative to the latter. Our empirical analysis finds a distinct effect of population ageing on these two categories. Specifically, we establish that country-level population ageing has a pro-environmental effect on nature-concerning outcomes and no clear effect on action-requiring environmental outcomes. Using an instrumental-variable strategy, we confirm the presence of a differential impact of population ageing on the two categories of environmental outcomes.

We also investigate the relationship between population ageing of the country of residence and individual environmental attitudes. At this level, we uncover the presence of a distinct pattern where being a resident in country with higher population ageing has a negative and statistically significant effect on individual participatory effort for the environment. By contrast, population ageing is found to have no effect on subjective attachment to the environment. Instead, the latter is driven by individual ageing with older age groups displaying higher attachment to the environment.

Our findings suggest several questions that future research shoud address. First, it is worthwhile to extend the analysis to identify the mechanisms that give rise to this differential impact of population ageing on environmental outcomes. One possible avenue would be through the effect that ageing may have on government expenditure. Perhaps population ageing puts significant strain on governments to provide costly public services such as pensions and healthcare. This, in turn, may reduce the funds needed to support action-requiring environmental outcomes such as investments in green infrastructure. It may also be the case that the elderly, who display a higher subjective attachment to the environment, support governments that are more prone to implement policies that preserve the nature environment. Finally, the results could be driven by the combined effect of the novelty of pro-environmental outcomes in the public sphere and the presence of habit inertia pertaining to pro-environmental behaviours. In that sense, the relatively high prominence of the elderly in ageing societies may be hindering the adoption of pro-environmental action at the individual level, thus resulting in the poor uptake of pro-environmental actions at the collective level.

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Appendix

Figure A1: Number of climate change laws and policies around the world in 2000

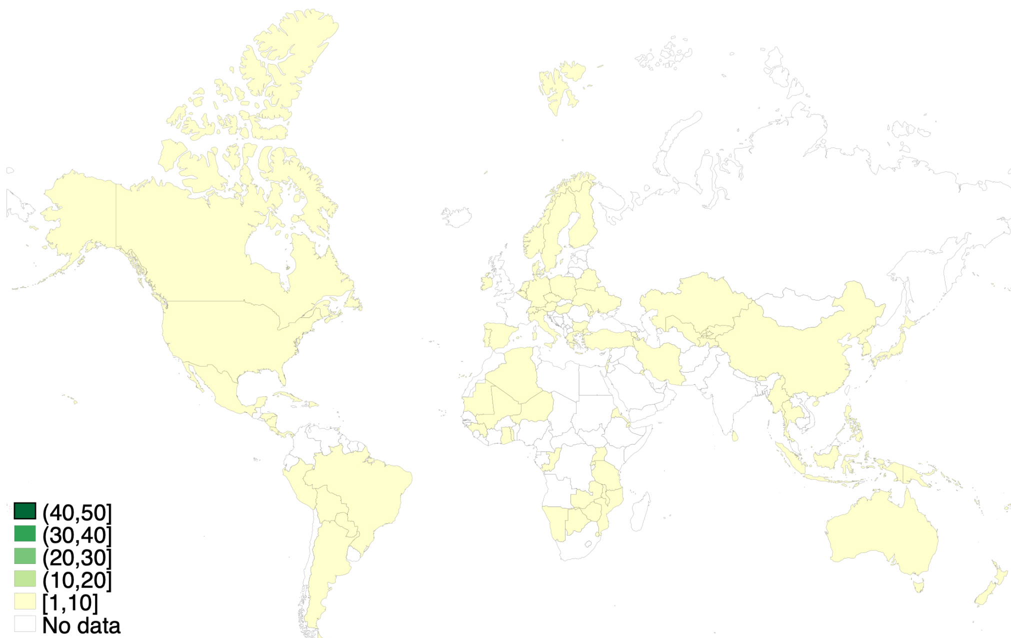

Figure A2: Number of climate change laws and policies around the world in 2020

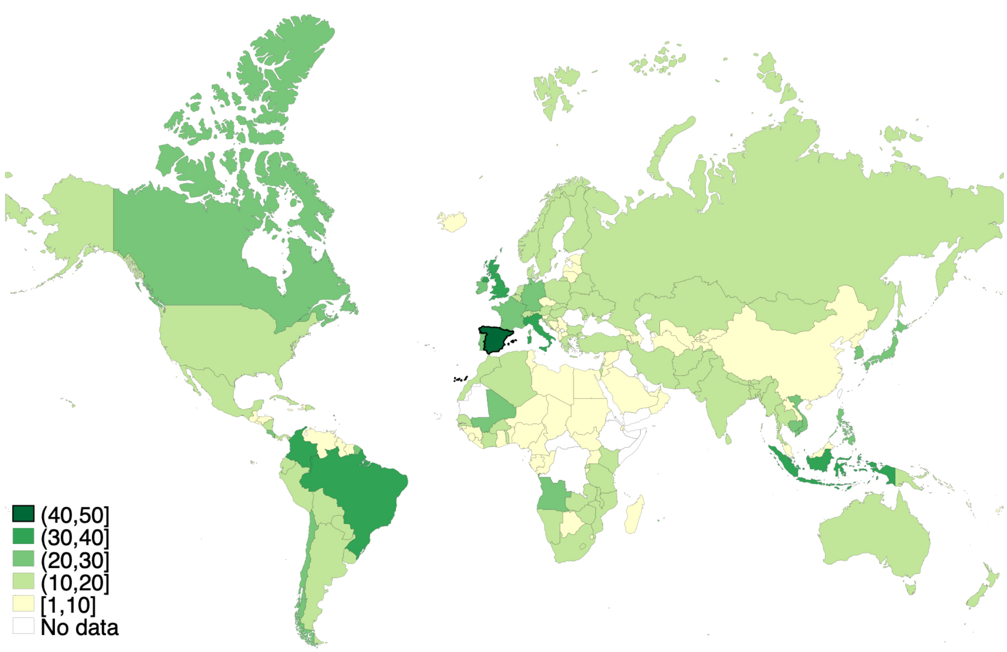

Figure A3: Countries in the baseline sample

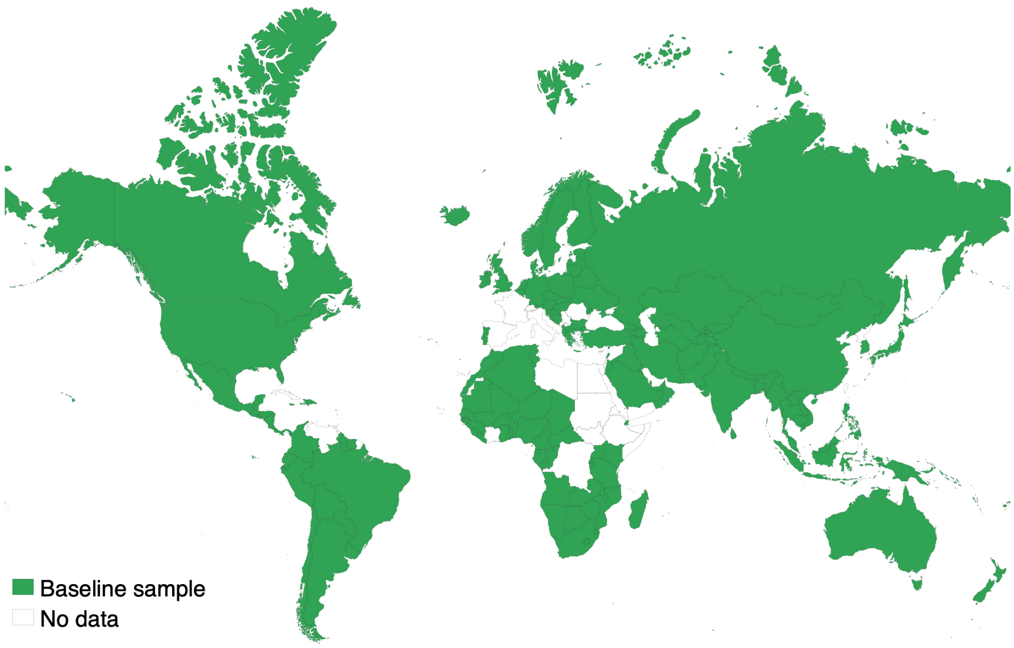

Table A1: Individual outcomes - List of sampled countries

Algeria	Armenia	Australia	Azerbaijan	Belarus
Brazil	Bulgaria	Burkina Faso	Canada	Chile
China	Colombia	Cyprus	Ecuador	Egypt
Estonia	Ethiopia	Finland	Georgia	Germany
Ghana	Haiti	Hungary	India	Indonesia
Iran (Islamic Republic of)	Iraq	Japan	Jordan	Kazakhstan
Kuwait	Kyrgyzstan	Lebanon	Libya	Malaysia
Mali	Mexico	Morocco	Netherlands	New Zealand
Nigeria	Norway	Pakistan	Peru	Philippines
Poland	Qatar	Republic of Korea	Republic of Moldova	Romania
Russian Federation	Rwanda	Singapore	Slovenia	South Africa
Sweden	Thailand	Trinidad and Tobago	Tunisia	Turkiye
Ukraine	United Kingdom	United States of America	Uruguay	Uzbekistan
Viet Nam	Zambia	Zimbabwe		

Table A2: The effect of population ageing of the country of residence on attitudes related to subjective attachment to the environment and participatory effort for the environment

	(1) Importance of environment	(2) Environmental organisation membership	(3) Importance of environment	(4) Environmental organisation membership
OADR	-0.036	-0.027***	-0.042	-0.028***
	(0.027)	(0.007)	(0.028)	(0.007)
Sex			0.060***	-0.012***
			(0.012)	(0.004)
Age			0.007***	0.000**
			(0.001)	(0.000)
Marital status			-0.012***	-0.000
			(0.003)	(0.001)
Employment status			0.005*	-0.004***
			(0.003)	(0.001)
Educational level			0.031***	0.011***
			(0.003)	(0.001)
Income level			-0.012	0.020***
			(0.015)	(0.005)
Population	-0.005***	-0.006***	-0.004***	-0.006***
	(0.001)	(0.000)	(0.001)	(0.000)
Rule of law	0.769	-0.206	0.861	-0.158
	(0.732)	(0.205)	(0.705)	(0.202)
Log of GDP per capita	0.192	-0.187*	0.123	-0.223**
	(0.401)	(0.107)	(0.403)	(0.109)
Rainfall	0.006*	-0.001	0.006*	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)
Temperature	0.168***	-0.028	0.156***	-0.023
	(0.059)	(0.018)	(0.059)	(0.017)
CO2 emissions per capita	0.018	-0.007	0.033	-0.001
	(0.047)	(0.017)	(0.046)	(0.015)
Country fixed effects	Yes	Yes	Yes	Yes
Survey year fixed effects	Yes	Yes	Yes	Yes
Observations	124615	124615	124615	124615
Adjusted R-squared	0.101	0.096	0.110	0.101

Summary: This table presents the OLS estimates of the relationship between country-level population ageing and individual environmental attitudes. It shows that population ageing of the country of residence has no significant effect on subjective attachment to the environment (*Importance of environment*) and has a negative effect on participatory effort for the environment (*Environmental organisation membership*). All specifications include country-level controls: total population, institutional quality, natural logarithm of GDP per capita, average yearly rainfall and temperatures and CO2 emissions per capita. Individual-level controls, sex, age, marital status, employment status, educational level and income level, are only included in the specifications shown in columns (3) and (4). All regressions feature country and survey year fixed effects.
Notes: (i) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (ii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.

Table A3: The effect of population ageing of the country of residence and individual ageing on attitudes related to subjective attachment to nature and participatory effort for the environment

	(1) Importance of environment	(2) Environmental organisation membership	(3) Importance of environment	(4) Environmental organisation membership
OADR	-0.042	-0.029***	-0.040	-0.028***
	(0.028)	(0.007)	(0.028)	(0.007)
25-34	0.046**	-0.002	0.047**	-0.000
	(0.021)	(0.006)	(0.021)	(0.007)
35-44	0.121***	0.007	0.097***	0.009
	(0.020)	(0.007)	(0.029)	(0.010)
45-54	0.183***	0.018**	0.131***	0.014
	(0.024)	(0.007)	(0.037)	(0.012)
55-64	0.270***	0.013	0.167***	0.002
	(0.030)	(0.008)	(0.045)	(0.014)
Above 65	0.349***	0.014	0.164***	-0.007
	(0.032)	(0.010)	(0.052)	(0.018)
Sex	0.061***	-0.012***	0.061***	-0.012***
	(0.012)	(0.003)	(0.012)	(0.003)
Marital status	-0.013***	0.000	-0.013***	0.000
	(0.003)	(0.001)	(0.003)	(0.001)
Employment status	0.005	-0.004***	0.004	-0.004***
	(0.003)	(0.001)	(0.003)	(0.001)
Educational level	0.031***	0.011***	0.032***	0.011***
	(0.003)	(0.001)	(0.003)	(0.001)
Income level	-0.013	0.020***	-0.013	0.020***
	(0.015)	(0.005)	(0.015)	(0.005)
Population	-0.004***	-0.006***	-0.004***	-0.006***
	(0.001)	(0.000)	(0.001)	(0.000)
Rule of law	0.836	-0.160	0.887	-0.154
	(0.702)	(0.202)	(0.701)	(0.201)
Log of GDP per capita	0.129	-0.220**	0.126	-0.219**
	(0.402)	(0.109)	(0.401)	(0.108)
Rainfall	0.006*	-0.001	0.006*	-0.001
	(0.003)	(0.001)	(0.003)	(0.001)
Temperature	0.158***	-0.023	0.156***	-0.023
	(0.059)	(0.017)	(0.058)	(0.017)
CO2 emissions per capita	0.032	-0.001	0.033	-0.001
	(0.046)	(0.015)	(0.045)	(0.015)
Observations	124615	124615	124615	124615
Adjusted R-squared	0.110	0.101	0.111	0.101

Summary: This table presents the OLS estimates of the relationship between country-level population ageing as well as individual ageing and individual attitudes towards the environment. It shows that population ageing of the country of residence has no significant effect on subjective attachment to the environment (*Importance of environment*) and has a negative effect on participatory effort for the environment (*Environmental organisation membership*). Furthermore, the regression results show significant differences in subjective attachment to the environment across age groups. All specifications include country-level controls: total population, institutional quality, the natural logarithm of GDP per capita, average yearly rainfall and temperature, and CO2 emissions per capita. They also include individual-level controls: sex, age, marital status, employment status, educational level and income level. Specifications presented in column (3) and (4) also include cohort fixed effects. All regressions feature country and survey year fixed effects.
Notes: (i) OADR is the ratio of the elderly population (aged 65 and above) to the working population (aged 15 to 64) (ii) standard errors are clustered at country and year level; robust and clustered standard errors are reported in parentheses; (iii) *** denotes statistical significance at the 1 percent level ($p < 0.01$), ** at the 5 percent level ($p < 0.05$), and * at the 10 percent level ($p < 0.10$), all for two-sided hypothesis tests.