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POPULATION AGING AND CARBON EMISSIONS: A NARRATIVE REVIEW OF INTERCONNECTIONS, IMPACTS AND POLICY IMPLICATIONS

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Abstract:

Population aging and climate change are two defining structural transformations of the twenty-first century. But their interrelationship is under-integrated across demographic, environmental, economic and policy scholarship. This article is a narrative review of the literature from 2000 to 2026. It seeks to untangle the effect of change in age structure on carbon emissions and account for the often mixed or contextual results in the literature. The review draws on studies on demographic transition, household consumption, energy use, labour supply, industrial restructuring, mobility and climate governance. The evidence is categorised under four themes: nonlinear and stage-dependent effects of aging; household consumption, residential energy use and mobility; labour supply, industrial restructuring and sectoral transmission; and spatial heterogeneity and demographic–climate policy integration. This synthesis suggests that aging populations are not inherently carbon-reducing or carbon-increasing. Its effects depend on interactions between reduced commuting and slower labour-force growth, changing consumption patterns, smaller household sizes, longer residential occupancy, demand for healthcare, technological change, energy systems and institutional conditions. The review also highlights continuing weaknesses in conceptual integration, sectoral coverage, terminology, measurement and models of policy implementation. Theoretically, it contributes to a more integrated understanding of aging as a structural demographic process operating through interlinked production, consumption and institutional pathways. It also stresses the need to consider age composition in

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climate projections and to align housing, transport, healthcare, energy, labour and social policies. Future research needs to be comparative, longitudinal, sector-specific, and equity-sensitive to identify the conditions under which aging societies can achieve inclusive low-carbon development.

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Keyword:

Carbon Emissions, Climate Policy, Demographic Transition, Energy Consumption, Household Carbon Footprint, Narrative Review, Population Aging

Introduction

Population aging and climate change are two of the most consequential global transformations of the twenty-first century. Health advances, decreasing fertility and increasing longevity are contributing to major changes in the age structures of populations in both developed and developing economies. By the late 2070s, the number of people aged 65 years and older is anticipated to be around 2.2 billion people globally, eventually exceeding the number of children under 18 years of age (United Nations Department of Economic and Social Affairs [UN DESA], 2024). This demographic transition is happening alongside a worsening climate crisis. In 2023, global greenhouse gas emissions were a record 57.1 gigatonnes of carbon dioxide equivalent, suggesting that current mitigation efforts are still insufficient to achieve the Paris Agreement's temperature targets (United Nations Environment Program [UNEP], 2024). It is well established that population size is a key determinant of environmental pressure. But demographic composition, and in particular the growing share of older people, may be just as important because it affects household formation, consumption preferences, labour supply, mobility, energy demand, public expenditure and patterns of economic production. Hence, the interaction between population aging and carbon emissions needs to be understood increasingly for designing climate policies that will remain effective under changing demographic conditions.

Yet the relationship between population aging and carbon emissions is neither straightforward nor unidirectional. Past scenario work indicated the potential of aging to moderate future emissions through reductions in labour-force participation, economic growth and some consumption and mobility (Dalton et al., 2008). Furthermore, empirical studies in recent years also suggest that the greater population aging may lower emissions through the declines in employment-related travel, industrial upgrading, energy conservation, and transition from carbon-intensive manufacturing to service-based economic activities (Xu, 2024; Zhou et al., 2023). However, aging can also mean more household energy use, as older adults tend to spend more time at home and may need more heating and cooling, medical care and assisted living services. Correspondingly, findings at the household level are mixed: some studies report an increase in household carbon emissions due to aging under certain urban, rural, income or climatic conditions, while others report a net effect of emissions reduction through changes in quantities of consumption and lifestyles (Fan et al., 2021; Ge et al., 2024). Moreover, the research based on threshold and nonlinear models suggests that the direction and magnitude of the relationship may change once certain thresholds in aging, urbanisation, trade openness, income, or industrial development are reached (Wang & Wang, 2021; Yang & Wang, 2020). These contrasting results suggest that population aging should not be treated as an inherently carbon-increasing or carbon-reducing process. Its ecological implications depend instead on the economic, institutional, technological, spatial and behavioural contexts within which demographic change occurs.

The scholarly interest has grown, yet the literature is still fragmented in several important ways. First, there is little conceptual integration. Various frameworks have been used in the literature, including Impact Population Affluence Technology (IPAT) and Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) models, environmental Kuznets curve specifications, panel threshold regressions, mediation models, general equilibrium simulations, and household carbon-footprint approaches, but the link between demographic change and a consistent set of behavioural, economic, and technological mechanisms has not been systematically established (Dalton et al., 2008; Jiang & Hardee, 2011; Li, Wang, & Li, 2024). Secondly, the evidence is mixed across sectors. Aggregate national and provincial emissions have received considerable attention, but household energy use and residential emissions are an increasing, yet geographically concentrated, area of research. Meanwhile, the effects of aging on transport, health care, waste generation, food consumption, public infrastructure, commercial buildings and embodied emissions in supply chains are not yet well integrated. Third, inconsistency in terminology and measurement. Researchers have depicted population aging in different ways, including the proportion of people aged 60 years and older, the old-age dependency ratio, median age, age-specific population shares, retirement status and life expectancy. Such differences hinder cross-study comparisons and may partly account for the mixed empirical findings. Fourth, regional and demographic heterogeneity is underexploited. There is evidence from Asian economies that the impact of age structure may not be uniform across countries, emission quantiles, age cohorts and between male and female populations, which highlights the limitations of treating older populations as a homogenous category (Syed & Rahut, 2024).

These limitations are reflected in a major policy and implementation gap. Climate strategies tend to be framed in terms of energy systems, technological innovation, economic growth, urbanisation and industrial transformation. Meanwhile, population aging is generally tackled through separate policies on healthcare, pensions, labour markets, housing and social protection. Consequently, few policy frameworks explicitly assess how changes in household composition, accessibility needs, residential occupancy, medical consumption, mobility and labour supply associated with aging may alter national decarbonisation pathways. Policy implications are also very context specific. For instance, reductions in emissions related to industrial upgrading and energy conservation in rapidly aging Chinese cities may not be directly relevant to countries where older households are heavily dependent on electricity generated from fossil fuels, private vehicles, poorly insulated houses, or care systems that are intensive in carbon use (Xu, 2024). Likewise, results from China, the US, South Korea, and Asian samples in general mirror varying energy structures, welfare arrangements, urban forms, income levels, and demographic transition stages (Choi & Kim, 2025; Dalton et al., 2008; Syed & Rahut, 2024; Zhou et al., 2023). Instead of universal prescriptions, it is therefore necessary to conduct a narrative review to synthesise these scattered results, to clarify the main pathways linking aging and emissions, to identify areas of consensus and disagreement, and to translate the evidence into flexible policy principles.

This narrative review therefore seeks to critically (i) synthesise the theoretical and empirical literature on the interconnections between population aging and carbon emissions, (ii) evaluate the principal mechanisms and sectoral impacts underlying this relationship, (iii) identify conceptual, methodological, geographical and implementation gaps, and (iv) derive policy implications for aligning demographic adaptation with low-carbon development [SE2.1]. The remainder of this paper is organised as follows. It first establishes the conceptual links between demographic composition and environmental pressure. The direct, indirect, non-linear, sectoral, regional and gender differentiated effects of population aging on emissions are discussed, as well as the economic, behavioural, technological and institutional mechanisms reported in the literature. Finally, it discusses policy responses, implementation challenges, research gaps and priorities for future investigation.

Review Approach

The present narrative review follows a semi-systematic synthesis approach to provide a transparent and structured review of the relationship between population aging and carbon emissions (Snyder, 2019). This study takes a narrative approach instead of a typical systematic review with a highly standardised protocol, which may conclude with a meta-analysis, to allow for greater flexibility in incorporating evidence that is conceptually and methodologically diverse (Green et al., 2006). Such an approach is especially suitable for the current review since the literature covers several related fields of research, such as demography, environmental economics, energy, household consumption, labour markets, industrial restructuring and climate policy. Thus, the review process was designed to identify recurring themes, competing explanations, theoretical linkages, methodological limitations, and policy implications across these related fields.

To improve transparency in the methodology and replicability, a systematic literature search was conducted using only Scopus database. Scopus was chosen for its wide coverage of peer-reviewed research within social sciences, environmental sciences, economics, energy studies and sustainability related disciplines. The search strategy was based on a combination of Boolean operators and pre-defined keyword clusters tailored to retrieve publications on the interlinkages between population aging, carbon emissions, environmental sustainability, and policy responses. Table 1 summarises the database, search fields, time frame of publication, search string, inclusion and exclusion criteria and approach to selection.

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Table 1: Summary of Search Strategy and Selection Parameters

Component	Description
Primary Keywords	"Population Aging," "Demographic," "Carbon Emissions," "Policy Implications"
Secondary Keywords	"Elderly," "Greenhouse Gases," "Ecological Impact," "Climate Change," "Mitigation"
Search string	("population" OR "demographics" OR "aging" OR "elderly") AND ("carbon emissions" OR "greenhouse gases" OR "CO2" OR "climate change") AND ("sustainability" OR "environment" OR "ecological impact" OR "carbon footprint") AND ("policy" OR "regulation" OR "mitigation" OR "adaptation")
Publication timeframe	January 2000–July 2026
Inclusion criteria	Peer-reviewed journal articles and review articles; publications written in English; studies examining population aging, age composition, older populations, longevity, or old-age dependency in relation to carbon emissions, greenhouse gas emissions, energy consumption, carbon footprints, climate change, or environmental sustainability; empirical, theoretical, modelling, and policy-oriented studies; studies reporting positive, negative, nonlinear, mixed, or statistically insignificant relationships
Exclusion criteria	Publications outside the specified timeframe; non-English publications; conference papers and abstracts, editorials, notes, commentaries, book reviews, and non-peer-reviewed materials; studies of biological or clinical aging without a population-level environmental connection; studies examining population size without a relevant age-composition dimension; studies in which aging or emissions were mentioned only incidentally; retracted publications; duplicate or incomplete records

A literature search for publications from 2000-2026 was performed. This period has seen the emergence of scholarship on the links between population composition, age structure, energy consumption and environmental pressure, with particular attention to the recent proliferation of studies on population aging and carbon emissions. The review retained previous studies that provided important theoretical or methodological bases, including demographic transition, IPAT, STIRPAT, life-course consumption, and population–environment viewpoints. The review focused on more recent empirical and policy-oriented studies, so as to capture recent changes in longevity, household structure, labour-force participation, energy systems and climate governance. The temporal scope allowed the review to follow the field from broad macro-level studies to more disaggregated studies of household carbon footprints, nonlinear effects, industrial restructuring, regional heterogeneity and demographic-responsive climate policy.

Studies were selected through a three-stage process of title and abstract screening, full-text assessment and thematic categorisation. Eligible studies examined population aging, age composition, older populations, longevity or old-age dependency in relation to carbon emissions, greenhouse gas emissions, energy use, carbon footprints, climate change or environmental sustainability. Peer-reviewed empirical, theoretical, modelling and review studies were retained regardless of the direction or statistical significance of reported effects (e.g. positive, negative, nonlinear, mixed and statistically insignificant effects). The selected studies were then classified into four themes: (i) Nonlinear and stage-dependent effects; (ii) Household consumption, residential energy use and mobility; (iii) Labour supply, industrial restructuring and sectoral transmission; and (iv) Spatial heterogeneity and demographic-climate policy integration. This semi-systematic narrative approach made it possible for the review to compare different methods and findings, while also identifying areas of convergence, divergence, conceptual fragmentation and policy relevance (Baethge et al., 2019; Ferrari, 2015; Snyder, 2019).

Conceptual Background

The conceptual background lays the theoretical and definitional groundwork for examining the relationship between population aging and carbon emissions. As this relationship operates through different demographical, economic, behavioural, technological and institutional pathways, it is pertinent to clarify the core concepts and analytical perspectives adopted in the literature. The following discussion begins with a definition of population aging and carbon emissions, and the different indicators and accounting approaches commonly used in empirical studies. It then reviews the main theories and frameworks relevant to the topic: demographic transition theory, IPAT, STIRPAT, life-course consumption, production-consumption pathways, the environmental Kuznets curve, and nonlinear or threshold perspectives. These concepts together provide an integrated basis for explaining why the environmental effects of population aging might differ across sectors, demographic stages, geographical settings, and policy contexts.

Definitions

“Population aging” is a permanent change in the age structure of a population in which the share of elderly persons grows. It is usually driven by long-term declines in fertility, falling mortality, and increased survival and life expectancy. From the demographic transition theory perspective, declines in mortality are typically followed by declines in fertility, leading to a gradual reduction in the relative size of younger cohorts and a gradual increase in the share of the population surviving to older ages (Kirk, 1996; United Nations Department of Economic and Social Affairs, Population Division [UN DESA], 2023). Therefore, population aging should be distinguished from individual aging. Individual aging refers to biological and social changes over the life course of an individual person, whereas population aging describes a change in the aggregate age structure of a society.

There’s no specific age cutoff for an older population. In international organisations and empirical studies, the age threshold, which is used to define older age, is commonly set at 60 or 65 years, depending on institutional, retirement and national demographic contexts. Population aging has been measured by means of indicators like the share of the population aged 60 years and over, the share of the population aged 65 years and over, the old-age dependency ratio, median population age, life expectancy and age-specific population shares. Conceptually related and distinct, these measures are . . . The proportion of older persons reflects the relative size of older cohorts. The old-age dependency ratio, however, compares older persons with the population traditionally designated as being of working age. Life expectancy is not the age composition of the population, but an average expected longevity. Therefore, studies using different aging indicators may reflect different dimensions of demographic change. The results may not be directly comparable all the time.

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In this review, the term of "carbon emissions" is primarily used to denote the anthropogenic carbon dioxide emissions, particularly from fossil fuel combustion, industrial production, energy use, land use change, transportation, buildings, and household consumption. Carbon dioxide is the largest component of anthropogenic greenhouse gas emissions, but the broader category also includes methane, nitrous oxide and fluorinated gases (Intergovernmental Panel on Climate Change [IPCC], 2023). Population aging studies employ a variety of related environmental outcomes including total carbon emissions, per capita emissions, carbon intensity, household direct emissions, household indirect emissions, residential energy related emissions, transport emissions and consumption-based carbon footprints. These outcomes are not equivalent because they differ in system boundaries, units of analysis and emission-accounting principles.

Direct household emissions are from fuels consumed directly by households, such as petrol used in private vehicles and natural gas used for cooking or heating. The indirect emissions are embedded in the production, transportation and delivery of the electricity, goods and services that the households consume. Territorial or production-based accounts assign emissions to the geographic location where they are produced. Conversely, consumption-based accounting attributes emissions to the final consumers of goods and services. The distinction is important for aging societies, in which older populations may decrease direct emissions by limiting mobility for employment purposes, but increase indirect emissions by increasing demand for electricity, healthcare, pharmaceuticals, care services, and age-supportive infrastructure. Environmental effects of aging may therefore be contingent on the level of emissions – household, sectoral, regional or national.

The conceptual connection between population aging and carbon emissions is more than a simple statistical correlation of the proportion of older persons with aggregate emissions. Population aging can influence emissions through changes in household structure, consumption preferences, residential occupancy, mobility, labour-force participation, savings, economic growth, public expenditure, industrial composition, energy demand and technological adoption 9, 10, 11, 12, 13 . These pathways are conditioned by income, urbanisation, household size, climate, welfare provision, energy systems, housing quality, gender roles and environmental regulation. Thus, in this review population aging is conceptualised as a structural demographic process, with environmental consequences stemming from the interlinked production, consumption and institutional pathways rather than from age composition per se.

Key Theories of Framework

The theory of demographic transition provides the basic explanation for the development of aging societies. The theory describes historical movement from regimes of high fertility and mortality to regimes characterised by low fertility, low mortality and longer life expectancy (Kirk, 1996). In the initial phases of transition, decreasing mortality rates result in population growth and a relatively young age structure. Fertility decline afterward reduces the size of younger cohorts while increased longevity increases the proportion of individuals reaching advanced ages. Therefore, population aging is a predictable long-term result of demographic transition and not an isolated social phenomenon (UN DESA, 2023). This framework is pertinent to carbon emissions, as different stages of demographic transition are linked with different patterns of labour supply, household formation, urbanisation, consumption, economic development and energy demand. It also suggests that environmental effects observed in countries at advanced stages of aging may not directly translate to countries at earlier stages of demographic transition.

Another key conceptual foundation is the IPAT framework. The IPAT equation describes environmental impact as the product of population, affluence, and technology, traditionally expressed as (I = P x A x T) (Ehrlich & Holdren, 1971). In this formulation, population is a measure of the magnitude of human demand, affluence is a measure of consumption or economic activity per person, and technology is a measure of environmental impact per unit of consumption or production. The framework recognises demographic processes as key drivers of environmental pressure. But the original formulation treats population mainly as an aggregate quantity. It does not explicitly discuss how populations of the same size, but different age structures may have different environmental impacts.

A life-course consumption perspective adds to STIRPAT by accounting for differential environmental demand between age groups. Consumption, income, time allocation, mobility, housing needs, health needs, and household responsibilities are systematically altered over the life course. Relatively high transport emissions among working age adults may be a consequence of commuting, employment and family-related travel. Older adults, however, may spend more time at home but travel less. Higher occupancy in residences may contribute to increased demand for lighting, heating, cooling, and household appliances, particularly where older adults are sensitive to temperature or live in small single-person households. However, in other contexts, retirement, lower income, reduced mobility and less material-intensive consumption may lead to a decline in emissions. Therefore, age composition affects different emission sectors through different behaviour mechanisms instead of a uniform decrease or increase in total consumption (Dalton et al., 2008; Liddle, 2011).

The life course perspective also draws attention to the significance of household structure. Population aging is often linked to widowhood, smaller households, intergenerational separation and a growing number of older people living alone. Smaller households can use less energy in absolute terms. But more energy per person is required for electricity, heating, cooling and appliance use, all shared by fewer occupants. Thus, lower mobility or consumption may partially offset the emissions-reducing effects of the loss of household economies of scale. The carbon impact of aging therefore depends on age as well as living arrangements, housing efficiency, household income, geographic location and access to public services.

A production-consumption pathway framework offers a more general macroeconomic explanation of the relationship. The production pathway can lead to a reduced share of the working-age population, changes in labour-force participation, slower economic growth, changes in savings and investment, and a shift from manufacturing to services. They can cut emissions by decelerating energy-consuming production or speeding up industrial upgrading. But emission reductions do not happen automatically: service sectors, health systems, digital infrastructure and care facilities also require energy and material inputs. Aging changes demand through the consumption pathway toward housing, health care, food, electricity, personal services and social care, possibly reducing demand for transport and some durable goods. Thus energy-economic modelling has shown that age composition can significantly change the long-term trajectory of energy use and emissions, even when the total population and technological conditions remain unchanged (Dalton et al., 2008).

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The environmental Kuznets curve is another framework to understand how economic development might influence demographic effects. It suggests that the extent of some types of environmental degradation may first increase with economic development and then decrease after incomes reach a sufficiently high level, because of structural economic change, technological improvements, stronger institutions, and a higher demand for environmental quality (Grossman & Krueger, 1995). When applied to population aging, this perspective suggests that aging may lead to higher emissions in economies where residential systems, health care provision, transport and electricity are still carbon intensive. But cut emissions in economies where technological development and structural transformation have weakened the link between consumption and fossil-fuel use. The framework does not imply that income is synonymous with environmental improvement. Instead, it seeks to identify the institutional and technological conditions under which demographic and economic change may be less carbon intensive.

The closely related nonlinear or threshold framework is Empirical evidence suggests that the effect of population aging is likely to change in magnitude or direction once specific demographic, economic or institutional thresholds are reached. Panel studies have found nonlinear effects of the degree of aging, economic development, urbanisation, industrial structure, trade openness and residential consumption (Li et al., 2023; Wang & Wang, 2021; Yang & Wang, 2020). Aging may first increase emissions through longevity, household consumption, healthcare demand, and residential energy use. However, if labour-force contraction, slower economic growth, industrial upgrading and reduced mobility take over, the effect may be dampened or even reversed. Similarly, Chinese census data show evidence of an inverted U-shaped relationship where aging initially increases emissions and then decreases them beyond an estimated turning point (Zhou et al., 2023). Threshold approaches thus challenge the idea that the relationship between aging and emissions can be fully described by a single linear coefficient.

To summarise, these theories provide the foundation for an integrated conceptual framework that distinguishes between direct, indirect and contextual effects. Direct effects are caused by differences in mobility, residential occupancy, energy use and consumption in relation to age. Indirect effects work through labour supply, economic growth, household formation, industrial restructuring, technological change, healthcare demand and public expenditure. Contextual factors such as income, gender, urban form, climate, welfare systems, housing efficiency, energy composition and environmental regulation may reinforce, attenuate or reverse these pathways. There are also possible feedback effects, as climate change could affect mortality, morbidity, migration, public expenditure and the vulnerability of older populations. Thus, this review perceives population aging and carbon emissions as a dynamic socio-environmental relationship that is affected by demographic transition, consumption behaviour, economic restructuring, technological condition and policy institutions.

Thematic Review of Literature

This review takes a thematic approach to synthesise and compare recurring findings, competing explanations and areas of scholarly disagreement. The evidence is structured around four interconnected themes: (i) nonlinear and stage-dependent impacts of population aging on carbon emissions; (ii) household consumption, residential energy use and mobility; (iii) labour supply, industrial restructuring and sectoral transmission; and (iv) spatial heterogeneity and demographic–climate policy integration. This framework allows a deeper critique of the

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mechanisms through which aging populations influence emissions, and highlights differences across sectors, demographic stages, places and policy contexts. Figure 1 presents the conceptual relations and analytical links between these themes.

Theme 1: Nonlinear and Stage-Dependent Effects of Population Aging on Carbon Emissions

The literature has increasingly conceptualised the relationship between population aging and carbon emissions as multidirectional and nonlinear, rather than a constant demographic elasticity. Aging can lower emissions, because it reduces labour-force growth, slows aggregate economic growth, reduces work-related mobility, and shifts from energy-intensive production to services. However, it could lead to higher emissions from longer stays in homes, smaller household sizes, increased demand for health care, ongoing consumption with longer lifespans and greater economic activity from healthier older people. Thus, the net environmental impact depends on the relative strength of production-side and consumption-side mechanisms. contextual conditions such as income, urbanisation, industrial structure, energy composition, technological progress and the stage of demographic transition also influence it. This interpretation is supported by threshold-based studies, which suggest that the level of emissions and the links between emissions and traditional drivers such as economic growth, energy use, residential consumption, and industrialisation can be altered by aging (Li, Zhu, & Wei, 2023; Wang & Wang, 2021; Yang & Wang, 2020).

A general trend in the empirical literature is that aging seems to become more and more emissions-reducing at later stages, but not always. Chinese census evidence suggests a possible inverted U-shaped relationship, with aging initially increasing emissions but decreasing them after a demographic turning point as lower consumption, reduced mobility and structural transformation become more important (Zhou et al., 2023). Threshold analyses across Chinese provinces and international samples also find that the magnitude or direction of the aging effect varies with the degree of aging, openness, industrial structure, urbanisation, and residential consumption (Li, Zhu, & Wei, 2023; Wang & Wang, 2021; Yang & Wang, 2020). But evidence from South Korea challenges the assumption that advanced aging will necessarily reduce emissions. Choi and Kim (2025) identified a link between higher emissions and higher economic participation among older adults, suggesting that increasing longevity, later retirement, and inadequate pension provision may extend carbon-intensive productive and social activities in later life.

Such disagreements suggest that neither chronological age nor the share of people above a certain age threshold may be sufficient to explain emission outcomes on their own. The literature tends to treat the share of the population age 60 or 65 and over as a relatively homogeneous indicator. Older populations are in fact highly heterogeneous in terms of health, wealth, employment, living arrangements, mobility and consumption capacity. Some of the estimated nonlinearities may also be due to differences in model specification, geographic scale, emission accounting, aging indicators, and missing institutional conditions, which are not universal demographic thresholds. Thus, further research is needed to disentangle true stage-dependent effects from method sensitivity and to assess whether the estimated turning points are robust across countries and periods. Also, this theme strengthens the overall purpose of the review by showing that population aging needs to be seen as a conditional structural process, and not as an inherently good or bad environmental force. Its carbon consequences are

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mediated by economic behaviour, institutional arrangements and the changing characteristics of successive older cohorts.

Theme 2: Household Consumption, Residential Energy Use, and Mobility

Household consumption is one of the main channels through which population aging impacts carbon emissions. Changes with age in income, household size, mobility, use of time, housing occupancy, use of appliances, demand for food and composition of expenditure, influence both direct energy consumption and the indirect emissions embodied in goods and services. Older adults may produce lower transport emissions, both because retirement reduces commuting and because mobility typically declines with age. At the same time, they may spend more time at home and need additional heating, cooling, lighting and medical or assistive equipment. Moreover, smaller, single-person older households may lose economies of scale, as fewer people share fixed residential energy needs. Therefore, emissions reductions in the mobility sector could be accompanied by an increasing demand for residential electricity or heating, leading to an overall household effect that depends on the categories of consumption included and the distinction between total, per capita, direct, and consumption-based emissions (Fan et al., 2021; Ge et al., 2024; Liddle, 2011).

The comparisons across studies show large differences across contexts of income levels and between analyses at the aggregate and the household level. In OECD countries, Liddle (2011) found that older age structures tend to be associated with lower transport emissions but possibly higher residential electricity consumption, demonstrating that the countervailing effects of aging are sector dependent. Evidence from 32 developed countries also suggests that older households can have relatively large consumption-based footprints because the accumulated wealth and carbon-intensive expenditure can allow consumption to remain high after retirement (Zheng et al., 2022). In contrast, in China, younger households may have higher household carbon footprints than older people since income and spending are concentrated among younger working-age groups (Tang et al., 2024). However, Chinese provincial and household studies have provided mixed evidence, with some finding emission reductions associated with more frugal consumption and lower income expectations. Conversely, others calculated nonlinear urban impacts or increases in specific residential categories induced by heating demand, household structure, and composition of consumption (Fan et al., 2021; Ge et al., 2024).

Hence the household literature cautions against the interpretation of low current expenditure by older adults as a long-term low-carbon aging effect. Future cohorts of older people may be healthier, wealthier, more technologically connected, more mobile and more likely to live independently than current cohorts. This could invalidate findings based on current retirees. Existing research also emphasises China, OECD economies and residential energy disproportionately. Meanwhile, evidence on food systems, waste generation, digital consumption, tourism, long-term care, pharmaceuticals and embodied emissions is still limited. Household surveys typically classify households based on the age of the household head, which can obscure the intergenerational makeup of households and the diversity among household members. Future research should integrate household composition, housing efficiency, climate conditions, health status, gender, wealth and urban accessibility with age-specific expenditure data. Based on the wider review, this theme demonstrates the importance of sectorally disaggregated, consumption-based analyses: aging could result in lower emissions in one category but higher in another, so aggregate estimates would be unable to identify the behavioural mechanisms relevant to policy.

Theme 3: Labour Supply, Industrial Restructuring, and Sectoral Transmission

Population aging also affects emissions through its influence on production, labour markets, innovation and the composition of economic activity. A declining share of the working age population may reduce labour supply and constrain aggregate output, thus reducing industrial energy demand and emissions. Faced with a shortage of labour, firms may respond by automating, substituting capital, investing in productivity or relocating, each of which may have different environmental consequences. Aging may also raise demand for health care, social care, pharmaceuticals, financial services and age-supportive infrastructure while reducing the relative importance of some manufacturing activities. Recent studies therefore distinguish between consumption-side channels (energy, residential and medical consumption) and production-side channels (industrial structure, research and development, technological progress and labour participation) (Li, Wang, & Li, 2024). This dual-pathway view helps to interpret the dual role of aging in both lowering emissions via slower production growth and raising them through changes in service and welfare demands.

The direction of these production effects depends on the economic structure and institutional context. General-equilibrium evidence from Italy indicates that pronounced aging can reduce economy-wide energy use despite shifts toward a potentially more energy-intensive consumption bundle, as the contractionary effects on economic activity dominate (Garau et al., 2013). Moreover, evidence from Chinese cities also shows that aging may reduce emissions by means of industrial upgrading and energy conservation, and industrial restructuring is an especially important indirect pathway (Xu, 2024). Other analyses have shown that energy constraints and industrial-structure changes are conducive to emission reduction, whereas increased consumption, technological progress, and labour participation may exert countervailing effects (Li, Jia, et al., 2024). Conversely, data from South Korea suggests that older adults who are economically active have a positive contribution to emissions, suggesting that extended working lives can support production-related emissions rather than necessarily reducing emissions as populations age (Choi & Kim, 2025). So, the debate is less on whether labour and industrial mechanisms matter, but more on how economies adjust to demographic contraction.

Important gaps remain in understanding these mechanisms. The expansion of service industries, for instance, is often interpreted as environmentally preferable to manufacturing because services are generally assumed to be less carbon intensive. This assumption may overlook the substantial direct and embodied emissions associated with hospitals, care facilities, laboratories, digital infrastructure, pharmaceutical production, and their wider supply chains. The implications of labour scarcity are similarly uncertain. A smaller workforce could encourage productivity improvements, automation, and low-carbon innovation, but it could also weaken research capacity, delay the replacement of inefficient infrastructure, or increase dependence on energy-intensive technologies.

Measurement presents another challenge. Much of the existing literature relies on broad indicators such as the share of the secondary sector, labour-force participation rates, or patent activity. Although useful, these measures provide limited information about workforce age composition, occupations, production technologies, innovation quality, or emissions embodied in domestic and international supply chains. Evidence also remains limited for sectors that are likely to become increasingly important as societies age, including healthcare and elderly care, construction, transport services, waste management, and the digital economy. Greater sectoral disaggregation would therefore help clarify where demographic aging generates additional environmental pressure and where it creates opportunities for emission reductions. Overall, the evidence suggests that the production-side effects of aging emerge through wider economic adjustment rather than demographic change alone. Whether this transition supports decarbonisation ultimately depends on whether responses to labour scarcity and changing demand encourage cleaner structural transformation or reinforce carbon-intensive technologies, services, and institutional arrangements.

Theme 4: Spatial Heterogeneity and Demographic–Climate Policy Integration

The environmental implications of population aging differ widely between countries, regions, urban and rural areas, income groups and demographic categories. Urbanisation, heating requirements, transport accessibility, energy prices, household wealth, welfare systems and electricity generation determine how similar age structures lead to different emission outcomes. Chinese research shows substantial urban–rural differences whereby rural older households may use less efficient fuels and housing, whereas urban households have more access to modern energy, public transport and services (Fan et al., 2021). Cross-country evidence also suggests that the relationship between age and emissions may vary across emission distributions and by sex and age group. For Asian economies, the authors find that working-age male and female populations are associated with higher emissions, while the effects of older populations vary by gender, illustrating how aggregate aging indicators can mask socially differentiated consumption and participation patterns (Syed & Rahut, 2024).

Comparative evidence also shows how aging-related policies can have emissions impacts beyond those captured by conventional climate strategies. In developed economies, the relatively high consumption footprints of wealthier older households provide the need for residential efficiency, low-carbon mobility, and consumption-oriented mitigation rather than assumptions that retirement will automatically reduce emissions (Zheng et al., 2022). In South Korea, as older adults' labour force participation increases, their productive and consumer roles need to be considered in carbon-neutrality strategies (Choi & Kim, 2025). Additional modelling for China indicates that relaxing fertility restrictions and delaying retirement may increase future household carbon footprints through population and labour supply expansions, even where these policies have demographic and fiscal benefits (Tang et al., 2024). At the urban level, the emissions-reducing effects of aging are stronger in high-income and low-emission cities, suggesting that industrial upgrading and energy conservation policies should be tailored to local development conditions rather than implemented uniformly (Xu, 2024).

The main gap is therefore not only the limited consideration of demographic change in climate policy but the limited integration of demographic objectives with energy, housing, transport, health care, labour and industrial policies. Policymakers rarely assess the environmental impacts of measures such as prolonging working lives, supporting fertility, expanding residential care, or enabling independent living at the time of formulation. In contrast, climate instruments may impose a disproportionate distributional burden on older households, given fixed incomes, thermal vulnerability, limited mobility options or reliance on medical equipment. Existing implementation models differ significantly and evidence from China, South Korea, OECD economies or individual cities cannot be transferred without considering

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institutional capacity, welfare provision, energy systems and cultural patterns. Therefore, a policy-assessment framework should integrate population projections and climate scenarios, consistent with the broader argument that demographic processes materially influence mitigation pathways (Jiang & Hardee, 2011). This theme links the evidence reviewed to the main goal of the article: to develop demographic-responsive climate policies that acknowledge heterogeneity, policy interactions, distributional outcomes and the need for context-specific implementation.

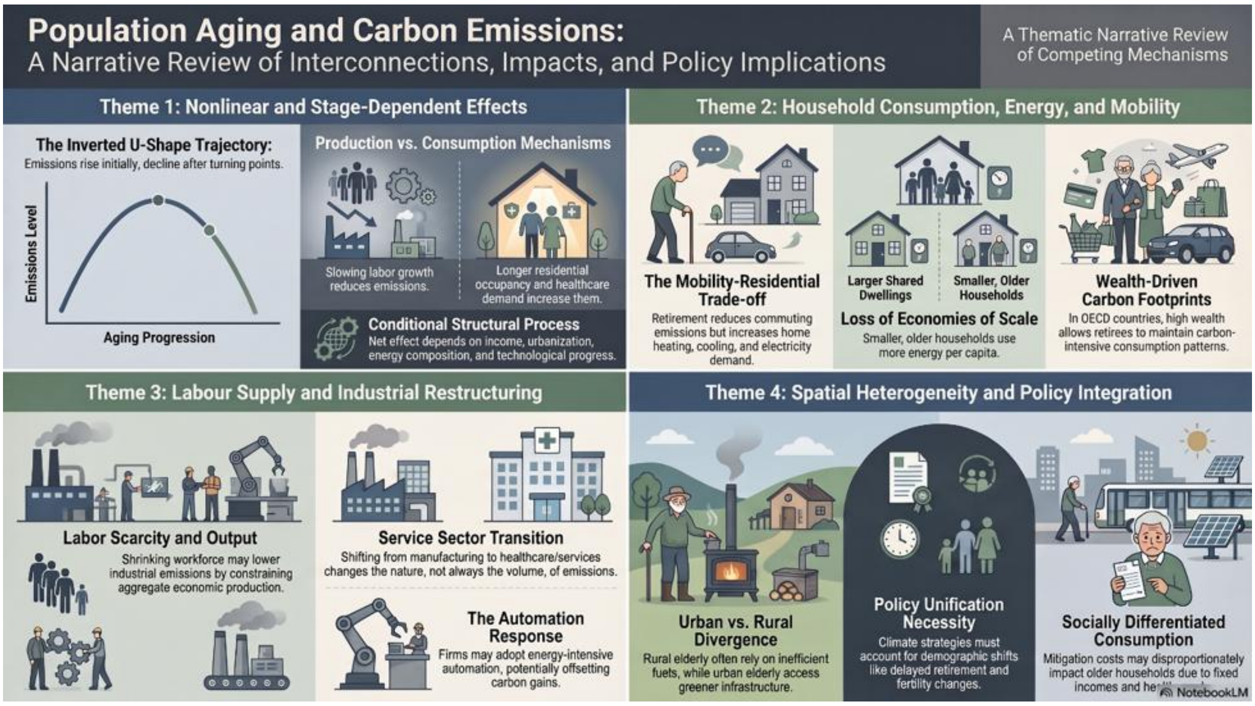

Figure 1: Thematic Review of Literature

Critical Discussion

The critical discussion is not just a descriptive synthesis of current studies but rather a critical evaluation of the coherence, limitations and broader significance of the literature. The analysis is organised around four dimensions: (i) areas of agreement, where findings and explanations converge; (ii) areas of disagreement, where empirical results or theoretical interpretations remain contested; (iii) gaps in current knowledge, including conceptual, methodological, sectoral and geographical limitations; and (iv) implications for future research, policy development and practical implementation. This structure makes it possible to assess the evidence in a more balanced way, as it explains how the literature reviewed contributes to understanding the relationship between population aging and carbon emissions.

Agreements in the Literature

One prevailing consensus is that population aging affects carbon emissions through a set of interacting channels rather than a single direct demographic effect. Macroeconomic, household and sectoral studies have linked aging to changes in labour supply, economic growth, household composition, mobility, residential energy demand, consumption preferences and industrial structure. The literature is also generally consistent that age composition provides information that cannot be captured by the total population size alone. Older societies may drive down work-related transport and some types of material consumption, but increase residential energy use, healthcare demand and emissions embodied in services. Thus, the environmental impacts of aging are a result of the interaction of production- and consumption-side mechanisms, with their relative importance varying across geographic and institutional contexts (Fan et al., 2021; Liddle, 2011; Li, Jia, et al., 2024; Zhou et al., 2023).

There is also broad agreement that the link between aging and emissions is context dependent and often nonlinear. Using threshold models, the effect of aging may be conditional on the degree of population aging, industrial structure, urbanisation, trade openness, residential consumption, and economic development (Li, Zhu, & Wei, 2023; Wang & Wang, 2021; Yang & Wang, 2020). This convergence is of theoretical importance, because it falsifies demographic models in which the effect of age structure is represented by a single constant coefficient. It also suggests expanding STIRPAT-like frameworks to include interaction terms, threshold effects, household characteristics and institutional moderators. In practice, policymakers should not count on aging as a friend or foe of decarbonisation. Its impact depends upon whether energy, housing, transport, health care and production systems allow demographic change through relatively low carbon pathways.

Disagreements in the Literature

The main difference is whether population aging will lead to more or less emission, and the magnitude of the impact. Lower labour participation, reduced mobility, slower economic expansion, industrial upgrading and energy conservation have all been found to reduce emissions in several studies (Xu, 2024; Zhou et al., 2023). Other evidence suggests that older populations are associated with sustained or increased emissions due to carbon-intensive household consumption, accumulated wealth, greater residential occupancy, longer working lives, and expanding demand for healthcare and other services (Choi & Kim, 2025; Zheng et al., 2022). And even within household literature, lower transport emissions may be linked with higher residential electricity consumption, and urban and rural households may respond differently to aging due to differences in income, fuel choice, housing efficiency, and access to services (Fan et al., 2021; Liddle, 2011).

Such disagreements do not necessarily mean that the evidence cannot be reconciled. Instead, they partly reflect differences in theoretical scope, measurement, analytical scale and national context. The aging is measured in several ways, such as the percentage of people 60 or 65 and older, the old age dependency ratios, the age-cohort shares, and the economic activity of older adults. They also look at territorial emissions, household footprints, transport emissions, residential electricity and emission intensity. Thus, it is possible to find a negative association at the national production level but a positive association in household consumption accounts. Furthermore, the outcomes from China, South Korea, OECD economies and cities also show very different welfare systems, energy structures, retirement arrangements and development paths. In principle, the field should move away from assuming a universally applicable direction of effect and instead identify the conditions under which specific mechanisms dominate. This empirically requires harmonised indicators and explicit comparisons of production-based and consumption-based emissions within the same analytical framework.

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Gaps

There are important gaps in the literature at the conceptual, methodological, sectoral and geographical levels. Many studies conceptually refer to mechanisms of production, consumption, technological and structural, but without connecting them to an explicit analytical framework. From a methodological point of view, the evidence still remains dominated by observational panel regressions, STIRPAT extensions, spatial models, and threshold estimations. These establish associations, but do not always sufficiently address endogeneity, reverse causality, cohort replacement, or policy feedback. Sectoral coverage is uneven: aggregate emissions, household consumption, residential electricity and transport are treated in some depth while healthcare and long-term care, pharmaceuticals, waste, food systems, tourism, digital services and age-supportive infrastructure are relatively underexplored. Geographically, the existing research is heavily biased toward China and developed economies. The generalisability of existing findings to developing countries undergoing simultaneous demographic, urban and energy transitions is very limited (Fan et al., 2021; Liddle, 2011; Zhou et al., 2023).

Also absent is the limited acknowledgement of heterogeneity among older populations. Older people are often considered to be a homogenous group, but there are large differences in sex, income, health, employment, ethnicity, household structure, housing tenure and rural/urban location. Cross-sectional estimates may also confound biological aging with cohort effects, as future retirees may have different amounts of wealth, mobility, familiarity with technology, and environmental preferences than current older cohorts. Research rarely considers the feedback effects that climate change itself may have on demographic processes through its impact on mortality, health, migration, care needs and public expenditure. These omissions matter because broad age-based classifications can hide both high-emitting groups and populations vulnerable to energy poverty or climate hazards. Future research should therefore integrate longitudinal household data, age-period-cohort methods, spatial analysis, input-output accounting and sectoral life-cycle evidence to distinguish age effects from the effects of generation, institutional factors and geography.

Implications

Our evidence review suggests that population aging should be explicitly taken into account in climate mitigation and adaptation planning. Typical national emission scenarios include total population and economic growth but have limited representation of age composition, retirement patterns, household size, demand for healthcare and mobility of older adults. Accounting for these factors would lead to better projections of residential electricity use, transport demand, service-sector growth and consumption-based emissions. Policy responses should include energy efficient, thermally safe housing; accessible public transport; low-carbon healthcare and care services; and support for sustainable consumption across the life course. Industrial and innovation policies need to anticipate the impacts of labour-force contraction, automation and service sector growth, rather than relying on the assumption that demographic aging will naturally lead to a less carbon-intensive economy (Choi & Kim, 2025; Xu, 2024; Zheng et al., 2022).

More fundamentally, policymakers need to evaluate demographic and climate policies together because interventions in one domain can have an effect on the other. Policies that postpone retirement, promote independent living, increase institutional care or alter fertility may all affect energy demand and household carbon footprints. By contrast, carbon pricing and energy-efficiency requirements may place a disproportionate burden on older people with fixed incomes, health vulnerabilities or limited mobility. Therefore, effective implementation requires context-specific coordination across climate, housing, transport, health, labour, pension and social-protection institutions. For theory, this supports a move away from population aging as an isolated explanatory variable toward considering it as a structural transition embedded within economic and institutional systems. The critical research and practice question is not whether aging is "good" or "bad" for emissions, but what mixes of policies can bring about a reduction in carbon intensity while safeguarding the welfare, accessibility and resilience of aging populations.

Recommendations and Future Directions

Those working in housing, energy, transport, healthcare, social care and community development should be aware that population aging can reduce some carbon-intensive activities, while increasing others. Reduced employment-related mobility could reduce transport emissions, but longer periods at home may increase demand for electricity, heating, cooling and household services. Practical interventions should therefore target energy-efficient and thermally safe housing for older residents, including better insulation, efficient appliances, passive cooling, accessible energy-management systems and tailored retrofitting support. These measures should cut emissions, without sacrificing thermal comfort, health, and affordability. Findings that the effects of age structure are different for residential and transport energy use further emphasise the importance of avoiding blanket assumptions about the environmental behaviour of older populations (Liddle, 2011).

Recommendations for Practice

Those working in housing, energy, transport, healthcare, social care and community development should be aware that population aging can reduce some carbon-intensive activities, while increasing others. Reduced employment-related mobility could reduce transport emissions, but longer periods at home may increase demand for electricity, heating, cooling and household services. Practical interventions should therefore target energy-efficient and thermally safe housing for older residents, including better insulation, efficient appliances, passive cooling, accessible energy-management systems and tailored retrofitting support. These measures should cut emissions, without sacrificing thermal comfort, health, and affordability. Findings that the effects of age structure are different for residential and transport energy use further emphasise the importance of avoiding blanket assumptions about the environmental behaviour of older populations (Liddle, 2011).

Transport and urban-service providers need to provide more accessible, low-carbon mobility options for older people so they can remain socially and economically active without increasing their reliance on private vehicles. Good public transport, safe walking facilities, closeness to services, community transport and age-friendly digital mobility platforms can support social inclusion and reduce emissions at the same time. Healthcare and social-care organisations should also look at where carbon emissions arise from service delivery, procurement, building operations, patient travel and home-based care. It should not be about limiting what is essential but how to provide it with lower carbon infrastructure, efficient logistics, renewable energy and co-ordinated local provision. Practitioners need to use disaggregated needs assessments, given significant variation among older populations in income, health, employment, location, and household composition and should not think of all older adults as a homogeneous consumer group.

Rather than viewing older adults as passive recipients of environmental policy, organisations should involve them as active participants in sustainability efforts. Community programs can help to increase energy literacy, reduce waste, make sustainable choices about food, repair and re-use items and consume responsibly in the household. These interventions should be accessible and affordable and responsive to differences in technological literacy and physical ability. Evidence at the household level suggests that the carbon implications of aging are partly conditional on health, composition of consumption, and living arrangements. Programs are therefore more likely to be effective when tailored to specific household types such as older couples, multigenerational households and older people living alone (Ge et al., 2024).

Recommendations for Policy or Organizational Use

Population aging should be explicitly incorporated in national and subnational climate strategies, emission projections, energy-demand models and urban-development plans. Demographic scenarios must not be limited to the total population size but must also include the age structure, household size, labour force participation, retirement patterns, longevity, health status, residential arrangements. This is important because the effect of aging is often non-linear and may differ across stages of demographic transition, economic conditions and industrial structures. Single assumption policies that aging increases or decreases emissions can misestimate future energy needs and mitigation needs. The evidence on threshold and census suggests that the aging effects may be heterogeneous by development level, regional conditions, industrial upgrading and demographic transition stage (Li et al., 2023; Zhou et al., 2023).

Governments and organisations need to enhance the coordination between climate policy and the institutions that are responsible for housing, pensions, employment, public health, transport, social protection and long-term care. Policies that promote delayed retirement, independent living, institutional care, or the growth of the service sector could have unforeseen carbon consequences if formulated without an environmental impact assessment. For example, the labour market participation of older adults could support economic and fiscal objectives. But it can also support commuting, energy use at the workplace and consumption-related emissions. Evidence from South Korea shows that economic activity of older populations can be positively associated with emissions, suggesting that demographic and labour policies should be considered along with decarbonisation objectives (Choi & Kim, 2025).

Distributional effects should also be considered in policy instruments. Carbon pricing, energy-market reforms and mandatory building upgrades may be felt hardest by older people living on fixed incomes or in inefficient housing. Targeted retrofit subsidies, social tariffs, accessible public transport and financial support for efficient medical or mobility equipment can cut emissions without leaving vulnerable households behind. However, some older groups in richer settings have considerable accumulated wealth and relatively carbon-intensive consumption patterns. Thus, mitigation policy should be differentiated by income and consumption, not age per se. Studies in developed economies suggest that population aging may make carbon mitigation more challenging if older households are wealthy and have large consumption-based footprints (Zheng et al., 2022).

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At the organisational level, public agencies, health care providers, pension funds, housing authorities and private sector service providers should integrate demographic-carbon indicators into strategic planning. Potential indicators include residential energy use by age and household type, transport patterns of older adults, carbon intensity of healthcare and care services and emissions from single-person households. Organisations need to set emission-reduction targets, consider demographic impacts when making investment decisions and disclose whether their decarbonisation pathways remain relevant in projected aging scenarios. Along the same lines, industrial and regional strategies should consider whether labour scarcity leads to technological upgrading orientated toward energy efficiency or substitution of labour by carbon intensive capital. Evidence from Chinese cities suggests that industrial upgrading and energy conservation can mediate an emission-reducing relationship between aging and carbon emissions, but such outcomes are contingent upon local economic and institutional conditions (Xu, 2024).

Future Research Directions

Future research should develop more integrated theoretical models linking demographic transition, life-course consumption, household structure, labour supply, industrial change, technological adoption, and demand for public-services. Many studies pinpoint individual mechanisms, but they do not describe how these mechanisms interact or change over time. An extended STIRPAT-type framework may contain age-group shares, household composition, participation in the labour-force, health expenditure, energy structure, urban form and institutional variables, as well as interaction and threshold terms. Researchers should also clearly distinguish between population aging, longevity, old-age dependency and older adults' economic participation as these indicators represent different demographic processes and may have different environmental effects.

The methodology should be more focused on causal identification and on the temporal dynamics. much of the evidence is based on aggregate panel regressions, spatial models or threshold estimations which might be subject to endogeneity, omitted variables bias and reverse causality. Future research could use natural experiments, policy discontinuities, longitudinal household panels, cohort-based designs, decomposition methods, structural modelling and quasi-experimental approaches. Age–period–cohort analysis in particular would be useful to disentangle changes related to biological aging from generational differences in wealth, technology use, environmental attitudes and consumption. Scenario modelling should also comparatively examine how alternative policies on retirement, fertility, migration, housing and energy interact to shape future emissions.

The sectoral evidence must be greatly increased. Much work has been done on aggregate carbon emissions, household consumption, transport and residential electricity, but relatively little is known about healthcare, long-term care, pharmaceuticals, food consumption, waste generation, tourism, digital services, institutional housing and age-supportive infrastructure. With an aging population and increasing demand for services, these sectors may become more important. Studies should integrate household expenditure surveys with environmentally extended input–output analysis and life-cycle assessment, to account for direct emissions and those embodied in supply chains. This is important because territorial emissions from industry may decline, while consumption-based emissions from imported goods and services may increase.

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Further research should increase the geographic scope of the study. Existing evidence is concentrated in China, South Korea, OECD countries and selected developed economies, with large gaps in the literature on Southeast Asia, South Asia, Africa, Latin America, and small island states. Advanced economies are not the only places where you might find aging–emissions relationships. In countries where aging, urbanisation, income growth and energy transition are all occurring together, the relationships could look quite different. Comparative research should assess how much the relationship of aging and emissions is moderated by the electricity generation, climate, welfare regimes, household structure, informal care systems, urban density, and cultural norms. The different patterns already identified between OECD economies, Chinese regions and South Korea suggest that findings should not be transferred uncritically across different contexts (Choi & Kim, 2025; Liddle, 2011; Zhou et al., 2023).

Finally, researchers need to explore the heterogeneity of older populations and evaluate policies based on their implications for both carbon reduction and social equity. Gender, income, health, employment, disability, household arrangement and urban-rural residence are likely to affect energy needs and the ability to adopt low-carbon practices. Climate policies need to be examined for whether they reduce or increase energy poverty, mobility restrictions and health risks in older people. Participatory studies with older adults, carers, practitioners and policymakers could enhance the practical relevance of proposed interventions. Future work should therefore move beyond estimating whether aging has an average positive or negative effect. Instead, it should identify what groups, sectors, institutions and policy arrangements can be conducive to low-carbon aging, while assuring wellbeing, accessibility and social inclusion.

Conclusion and Limitations

This narrative review shows that the link between population aging and carbon emissions is complex, multidimensional and highly context specific. Population aging can reduce carbon emissions by reducing employment-related mobility, limiting labour force expansion, reducing energy-intensive production, and promoting industrial restructuring. At the same time, it can increase environmental pressures through smaller household sizes, longer residential occupancy, persistent consumption among wealthier older cohorts, and increasing demands for electricity, health care, long-term care and other services. Evidence of non-linear and threshold effects further shows that the direction and magnitude of these effects differ across different aging stages, levels of economic development, energy structure, urbanisation, and institutional environment (Li et al., 2023; Zhou et al., 2023). Population aging should therefore not be viewed as an inherently carbon-reducing process, nor as an unavoidable source of additional emissions.

This review makes a central contribution by bringing together evidence that is often considered separately from demographic, household, economic, sectoral and policy perspectives. The review sheds light on the literature in a thematic fashion and identifies the significance of age composition on emissions through interlinked consumption and production pathways. It also demonstrates how apparently contradictory findings can co-exist. For instance, there is scope for decoupling of transport emissions with increasing residential energy use and of territorial emissions with high consumption-based footprints of wealthy older households (Liddle, 2011; Zheng et al., 2022). These results emphasise the significance of differentiating between emission categories, geographical scales, household compositions, age groups and accounting methods when assessing the environmental consequences of demographic change.

The review also adds to policy and practice by emphasising demographic aging as a cross-sectoral consideration in climate governance. Climate strategies should be based on changes in age structure, household composition, retirement behaviour, healthcare demand, mobility and labour supply, rather than on aggregate population projections. A combination of interventions in housing, energy, transport, health care, industrial development, pensions and social protection will be key to ensure decarbonisation is effective and socially equitable. Future progress will hinge on moving beyond the question of whether population aging increases or decreases emissions. Instead, more attention needs to be paid to the institutional, technological and behavioural conditions that influence these effects and enable societies to deliver healthy, inclusive aging within low carbon development pathways.

Limitations

There are some limitations that should be considered in interpreting this review. The literature search was initially limited to the database Scopus. Thus, relevant studies indexed only in Web of Science, PubMed, regional databases or specialist repositories may have been missed. The review also excluded grey literature, government reports, working papers, dissertations and non-indexed policy documents. In addition, the review covered publications from January 2000 to July 2026 and was limited to the English-language peer-reviewed literature. Such boundaries made the review more tractable and consistent. But they may have missed earlier seminal contributions, recent studies that are not yet indexed in Scopus, and evidence from non-English speaking contexts.

Second, the existing literature exhibits a clear geographical and sectoral imbalance. Most empirical evidence is from China, OECD countries and a few other developed or rapidly aging economies. Therefore, the results may not be directly generalisable to other countries experiencing aging in the face of fast urbanisation, lingering energy poverty, informal employment, and fossil fuel dependent development. The research also looks at aggregate emissions, household consumption, residential energy and transportation. At the same time, healthcare, long-term care, pharmaceuticals, waste, food systems, tourism, digital services and age-supportive infrastructure remain relatively under-represented. The synthesis therefore mirrors the structure of the available evidence rather than an even coverage of all regions and emission producing sectors.

Third, conceptual overlap and inconsistency in measurement limited direct comparison between studies. Population aging was represented in various forms such as older-age population shares, old-age dependency ratios, median age, life expectancy, cohort composition, retirement status and labour-force participation of older people. Similarly, environmental outcomes included territorial carbon dioxide emissions, greenhouse gas emissions, emission intensity, residential energy emissions, transport emissions and consumption-based carbon footprints. Though related, these variables capture different demographic and environmental processes. A narrative synthesis might reveal broad patterns of combining them. However, it cannot guarantee that the results of one indicator or accounting framework can be directly compared with the results of another.

Finally, the narrative review methodology involves interpretive judgement. Identification and selection of studies was based on a priori criteria. Interpretive judgements were necessary, however, to determine conceptual relevance, to assign studies to themes, and to assess competing explanations. The review did not conduct meta-analysis, pooled effect estimation or a formal risk-of-bias assessment due to high diversity of the included studies in terms of design, variables, geographical scale and analytical methods. Narrative reviews can summarise heterogeneous evidence and generate conceptual understanding. However, the credibility of such does depend on transparent search procedures, appropriate referencing, and balanced interpretation (Baethge et al., 2019). Thus, the conclusions should be interpreted as an important synthesis of the existent literature rather than a pooled statistical estimate of the effect of population aging on carbon emissions.

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