DEMOGRAPHIC CHANGE AND THE FUTURE OF RESILIENCE PLANNING IN MOLDOVA

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Nicholas GAILEY

PhD, Wittgenstein Centre for Demography & Global Human Capital, International Institute for Applied Systems Analysis, Austria

https://orcid.org/0009-0002-7176-5505
gailey@iiasa.ac.at

Olga GAGAUZ

PhD habilitation in sociology, associate professor, National Institute for Economic Research, Academy of Economic Studies of Moldova

https://orcid.org/0000-0002-1175-1008
gagauz_olga@ince.md

Irina PAHOMII

PhD student, Charles University in Prague, Faculty of Sciences, Department of Demography and Geodemography, National Institute for Economic Research, Academy of Economic Studies of Moldova

https://orcid.org/0000-0002-6595-9146
pahomii.irina@ase.md

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SUMMARY

Demographic transformation is a defining global trend, and Moldova is undergoing profound structural shifts that reflect this broader pattern. The country's population is shrinking, aging, becoming more educated, and more economically active—trends that carry wide-ranging implications for public policy, economic resilience, and long-term development. This paper analyzes how these demographic changes will affect the future demand for critical services and infrastructure by 2050. Using scenario-based population projections, the study estimates population-based demand across four key sectors: education, health, social protection, and physical infrastructure. The analysis distinguishes between a baseline scenario, where current population-to-infrastructure or population-to-service ratios are maintained, and a continued development scenario, where the ratios improve over time. The results reveal that demographic decline creates opportunities to enhance efficiency in sectors like education and housing, while also generating pressure to restructure services in health care and social protection due to population aging. The study highlights the importance of 'demographic resilience' as a policy framework—defined as a society's capacity to anticipate, absorb, and adapt to demographic change through strategic planning and human capital investment. By integrating demographic evidence into cross-sectoral policymaking, Moldova can best position itself for achieving lasting demographic resilience. This study advances the concept of demographic resilience by demonstrating how strategic investment in human capital can offset the challenges of population decline and aging.

Keywords: *population projections, public service demand, demographic resilience*

INTRODUCTION

Across the globe, countries are undergoing complex demographic transformations that challenge the foundations of economic planning, social protection systems, and public service delivery. Moldova is no exception. With a population that is shrinking, aging, and increasingly mobile, the country is experiencing structural shifts that will fundamentally reshape future demand for services, infrastructure, and human capital investment. These demographic trends—especially when compounded by ongoing external shocks such as regional instability, economic migration, and energy crises—demand timely, evidence-based responses and integrated resilience strategies.

In recent decades, Moldova has seen steady increases in life expectancy, gradual improvements in health indicators, and rising educational attainment. At the same time, the country is marked by low fertility, a high rate of out-migration—particularly among youth and professionals—and a rapidly ageing population. The projected decline in the number of residents, especially in rural areas, combined with pronounced generational imbalances, will have far-reaching consequences for the sustainability of public services and potentially the country's economic competitiveness.

In response to these challenges, we developed national population projections for the period 2023–2050. These projections serve as a critical tool for informing long-term policy decisions across several key sectors: education, health, social protection, and physical infrastructure. The present article builds on these projections and introduces the concept of demographic resilience—defined as the capacity of a society to anticipate, absorb, and adapt to demographic change through informed governance and investment in human capital.

This study has three interrelated objectives:

1. To assess Moldova's medium-term demographic outlook using scenario-based population projections;
2. To estimate future demand for public services and infrastructure under both baseline and improving assumptions;
3. To explore the policy implications of these projections for enhancing Moldova's demographic resilience.

Unlike traditional demographic analyses that focus narrowly on fertility, mortality, and migration trends, this study adopts a systems perspective, recognizing the interdependence between demographic dynamics and sectoral planning. The review explores how age structure transformations affect demand for schools, health service needs, pension system sustainability, and infrastructure demand. It also discusses how changes in human capital composition—particularly rising levels of education and labor force participation—can act as counterweights to a shrinking population size.

The review argues that demographic change should not be viewed solely as a threat but also as a window of opportunity for smart adaptation, if anticipated and managed well. There is a need to rethink the economy and society, adjust social and health, and develop new approaches to social care (Warner et al., 2025). In this context, the demographic resilience approach provides a roadmap for Moldova to align its investments, policies, and institutional capacities with the population of tomorrow.

LITERATURE REVIEW

The demographic transition observed in Moldova reflects broader patterns documented in Eastern Europe and globally, where declining fertility, increased longevity, and sustained emigration are reshaping the population structure (Lutz & KC, 2011; UN DESA, 2022). Moldova's contemporary demographic outlook is broadly in line with the predictable patterns seen worldwide in post-Demographic Transition countries, with additional nuances from the legacies of the post-Soviet economic instabilities and interactions with other economies in the region. At the same time, Moldova's demographic outlook is also a product of unfavourable trends, such as ongoing "brain drain" with many Moldovans searching for work in other economies (Tabac, 2021; Gagauz, Tabac &Pahomii, 2023). Fertility also remains moderately low (1.6), with couples having notably fewer children than they desire (Grigoraş & Gagauz, 2022).

These shifts generate complex challenges and opportunities for social and economic development, requiring robust, evidence-based strategies to ensure demographic resilience (Bloom et al., 2011). The concept of demographic resilience has emerged as a multidimensional policy framework that moves beyond population numbers to incorporate structural adaptability, human capital investment, and institutional preparedness (UNFPA, 2021). In this context, population projections are not only technical tools but also strategic instruments for anticipating change and guiding long-term public planning (Wilson & Rees, 2005).

Moldova's demographic context is shaped by both general transition trends and unique contextual features, such as its historical exposure to post-Soviet disruptions, economic migration, and limited fiscal space for reforms (World Bank, 2023). International assessments have consistently highlighted the importance of aligning demographic foresight with investment in education, health, and social protection to ensure sustainable development (OECD, 2019; WHO, 2021). Sectoral analyses, particularly in the fields of education and health, reaffirm that population aging and childbearing declines demand strategic realignment rather than simple expansion or contraction of services (Lee & Mason, 2011). Education system adaptation, labor force participation, and healthy aging are key levers in transforming demographic vulnerability into long-term opportunity (Cuaresma et al., 2014b; Cylus & Al Tayara, 2021).

While a growing number of high-income countries have adopted policy innovations to link retirement age to life expectancy and reduce generational imbalances in social spending, similar reforms in low- and middle-income countries often face constraints due to informality, political cycles, and lower institutional trust (Esping-Andersen, 1999; Holzmann et al., 2019). In this regard, Moldova offers a compelling case study of how demographic evidence, when systematically integrated into national planning, can contribute to both fiscal responsibility and social sustainability.

DATA AND METHODS

The methodological framework of this study comprises two core components: the development of a national population projection for the period 2023–2050 and the construction of a scenario reflecting future service demand.

POPULATION PROJECTION

The analytical approach is grounded in the cohort-component method, a widely recognised demographic technique for population forecasting (Mazzuco & Keilman, 2020; Vanella, Deschermeier, & Wilke, 2020). This method allows for systematic projections by applying age- and sex-specific assumptions on fertility, mortality, and migration.

The base data used in this study derive from official sources provided by the National Bureau of Statistics (NBS) of Moldova. These include detailed data on population size and structure, as well as vital statistics concerning fertility, mortality, and migration. The use of official statistical data ensures consistency and reliability in the projection exercise.

The population projection is deterministic in nature and does not represent an official forecast. Rather, it serves as a scenario-based exercise that illustrates the demographic implications of a hypothetical, yet plausible, path informed by current trends. The purpose of this scenario is not to predict future demographic developments per se, but to simulate conditions under which policy responses may be evaluated in a sustainability-oriented context.

In this study, a single scenario was presented, reflecting an optimistic view, but grounded in the observed trends in data trajectory. The following assumptions were applied:

- *Fertility:* The Total Fertility Rate (TFR) begins at 1.7 children per woman in 2023, decreasing to 1.6 by 2040 in alignment with observed regional trends. By 2050, a modest increase to 1.8 is assumed. These values are supported by findings from the Generations and Gender Survey, which indicate that fertility intentions in Moldova remain relatively high compared to EU averages.
- *Mortality:* Life expectancy at birth for females increases from 76.0 years in 2023 to 83.6 years in 2050, while for males, it rises from 67.5 to 76.7 years. These assumptions imply a gradual reduction in the gender gap in life expectancy, from 8.5 years to 6.9 years.
- *Migration:* Migration assumptions are based on pre-pandemic patterns, excluding data for the years 2020–2022, which were affected by exceptional circumstances. A progressive decline in net migration is assumed—60% for males and 70% for females—by 2040. In addition, the age profile of migration is adjusted to reflect lower net emigration among young children and working-age adults, alongside stabilisation of immigration among older returnees (aged 60+). This profile remains constant between 2040 and 2050.

All calculations were performed using the DAPPS software (Demographic Analysis and Population Projection System), a tool developed to facilitate cohort-component projections and demographic analysis. DAPPS offers a user-friendly environment suitable for constructing both national and sub-national projections and is widely used in demographic planning and policy evaluation.

This projection provides the demographic foundation for the assessment of future service demand. While not exhaustive, the chosen assumptions aim to reflect the most relevant demographic processes shaping Moldova's medium-term outlook.

SCENARIOS FOR FUTURE DEMAND

Future demand for various services, infrastructure, and resources has a direct relationship with demographic change (including specific sub-populations, e.g. age cohorts). As such, population projections are a tool that can be used to guide the government's planning and allocation of public funds. This review explores that relationship for subsets of the following sectors:

- Childcare & Schooling;
- Health Services;
- Social Protection;
- Physical Infrastructure & Resource Consumption.

Drawing from available official data, specific indicators of interest were selected for each sector. In most cases, the indicators included in the study were chosen based on the availability of up-to-date statistical data and their relevance to fulfilling the basic needs of the population or advancing strategic policy objectives.

For the Childcare & Schooling sector, the following indicators were selected: child care facilities, kindergartens, early education staff, primary schools, secondary schools, and primary and secondary school teachers. Data for these indicators, corresponding to the base year, were retrieved from the National Bureau of Statistics (NBS).

For the Health Services sector, the analysis included the following indicators: total number of hospital beds, maternity ward beds, geriatric beds (with a therapeutic profile), geriatricians, total number of doctors, nurses, midwives, paediatricians, neuropathologists, and pharmacists. Data were sourced from the NBS, except for the number of geriatric beds (therapeutic profile), which was obtained directly from the competent institutions.

For the Social Protection sector, the indicators used were: parental leave benefits (2-year option), parental leave benefits (3-year option), pension benefits, and unemployment benefits. Information on child-related allowances and pensions was extracted from the records of the National Office of Social Insurance of Moldova, while data on unemployment benefits were obtained from budget expenditure documents by category of social transfers.

For the Physical Infrastructure & Resource Consumption sector, the selected indicators included: public transport (buses and minibuses), private transport (cars and taxis), housing units, electricity consumption (in millions of kWh), total energy consumption (in tons of oil equivalent – TOE), CO_2 emissions (in millions of tons), solid waste generation (in tons), volume of water supplied to the population through public infrastructure (in thousand m^3), and volume of wastewater discharged into the public sewage system (in thousand m^3). The primary source for all base year data in this sector was the National Bureau of Statistics (NBS).

Based on the observed current values for the indicators of interest, this research explores two distinct scenarios for their future development.

- ***Baseline (maintaining current ratios):*** The current proportion of indicator X (social and physical infrastructure) to population (in the relevant age group) is held constant through 2050. *E.g., The number of teachers declines proportionately with the population of school-aged children, maintaining the teacher-to-pupil ratio.*
- ***Continued Development (improving ratios):*** The current proportion of indicator X (social and physical infrastructure) to population (in the relevant age group) is improved by 0.5% per year through 2050. *E.g., The number of teachers declines slower than the population of school-aged children, gradually improving the teacher-to-pupil ratio.*

Once the future demand is estimated, the research moves on to consider implications for policy. Specifically, it presents challenges and opportunities in the various sectors considered, explicitly in terms of ongoing demographic change. Policy options are considered to strengthen human capital and lean into the potential for a Demographic Dividend, and by extension achieve demographic resilience.

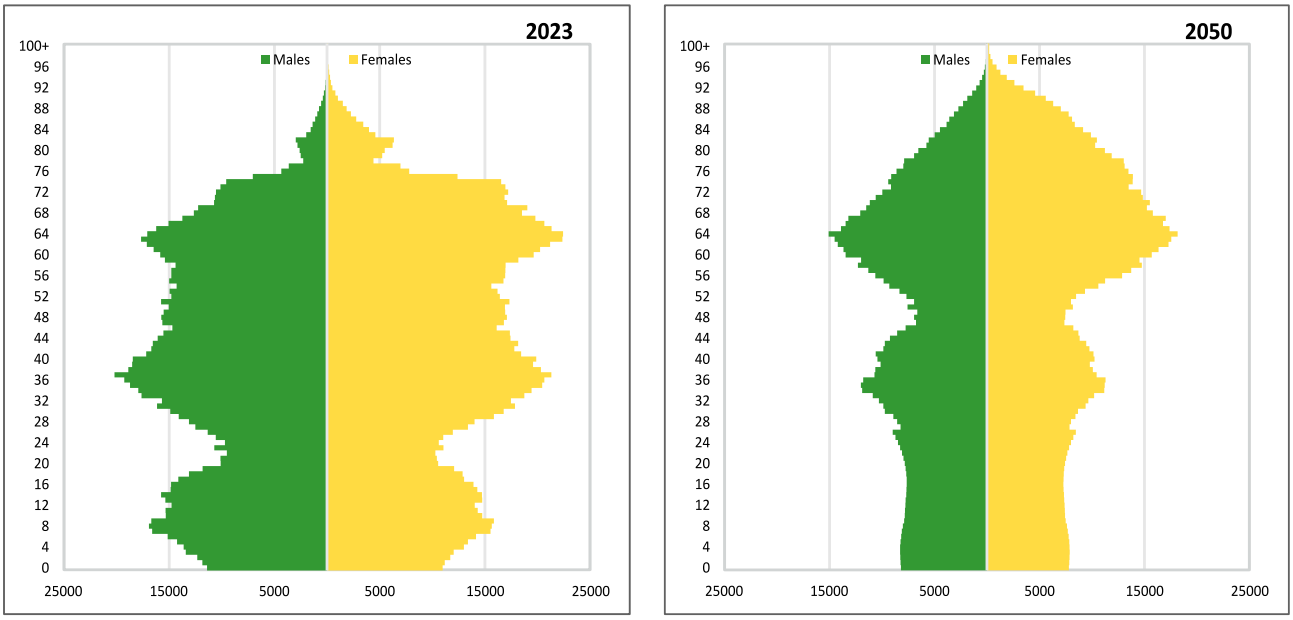
DEMOGRAPHIC BACKGROUND

Results of the projection indicate that Moldova's actual resident population (excluding emigrants and seasonal workers) declines from 2.42 million in 2024 to 1.7 million in 2050, assuming fertility remains moderately low, and emigration remains relatively high (*Figure 1*). This decrease is 20% faster than what is projected for the Eastern European region (UN, 2024) during the same period. In highly developed, post-Demographic Transition settings, the consequences of population decline are complex. It brings the potential to free up more resources per capita (natural and social) and facilitate higher standards of living, but it also can be associated with reduced economies of scale and provision of services in rural areas.

Compounding the challenges of population decline, Moldova also faces significant generational imbalances. The cohorts born around the year 2000 are about half the size of that born in 1990, and three-fourths of that born in 2010. These variations stem from a combination of effects from historical events (World War II casualties and post-Soviet repatriations), ongoing emigration of Moldovans (disproportionately young), and social changes (delayed childbearing). While Moldova has adapted to past fluctuations in the size of generations by condensing (and then expanding again) services in the last 30 years, the imbalances continue to pose obstacles for planning and resource allocation, particularly in education and healthcare.

Figure 1.

Population Age-Sex Pyramids, 2023 and 2050



Source: NBS data for 2023 and projection for 2050.

Moldova's population is also at the forefront of the aging global megatrend (Gagauz et al., 2024). In recent decades, population aging has advanced with longer lifespans, particularly among men who previously died quite young by international standards. At the same time, Moldova has the second factor of emigration, which has remained disproportionately made up of the youth amid waves of those leaving since independence. Still, Moldovans today are younger than Western Europeans on average, and roughly on par with their Eastern European peers. However, the pace of aging is comparatively quick. The results of the projection suggest that the share of Moldovans aged 65+ will grow from 17.4% (2023) to 30.4% (2050), and the median age rises from 40.4 (2023) to 50.3 years (2050).

Population aging and decline are two noteworthy trends captured by the projections used in this review, but these trends are not unfolding in isolation. Simultaneously, Moldova is seeing gains in its human capital, as the population becomes more educated and more active in the labor force over time. By 2050, the proportion with upper secondary or higher education is projected to jump to 77.3% up from 14.8% in 1970 (Wittgenstein Centre for Demography and Global Human Capital, 2023). Similarly, labour force participation is on the rise, increasing from an overall rate of 42% in 2019 to 45% in 2023, with participation approximately 20 percentage points higher for Moldovans with post-secondary education compared to the overall participation rate. While these suggest positive signals for human capital, the 'quantity' of education or labour force participation is not enough in itself to secure a resilient society. Human capital must also be of high quality; otherwise, its significance and potential as a force for socio-economic development are diluted.

Ultimately, what makes a country successful depends on much more than the simple population size or age structure. The characteristics of its people, including their skills and abilities, are of great consequence. Many of today's most prosperous, safe, and livable societies do not have particularly large population sizes, or even external sources of wealth (e.g. natural resources), but rather a cultivated population. Put another way, demographic change doesn't always require demographic solutions. Much of the broad demographic change, with the momentum behind it, is essentially inevitable in any case. The degree to which governments can plan accordingly, and leverage human capital, will determine the resilience of societies.

MAIN RESULTS

CHILDHOOD & SCHOOLING

In life's most formative years, childcare and childhood education are expected to equip the next generation with essential skills for excelling in life. How children fare in these settings often carries with them well into adulthood, showing a clear association, if not causal relationship, with higher education, income, sociability, criminality, and many other life outcomes (OECD, 2023). Education is even found to have a strong relationship with health, as mortality reduces by 2% with every year of schooling (Institute for Health Metrics and Evaluation, 2018). Therefore, it is clearly in the public interest to invest in education and help children reach their fullest potential.

Table 1 shows the future demand for such services in Moldova. Since the country's population decline is disproportionately among children and women in their childbearing years, it creates a comparatively quick drop in demand for the child-focused infrastructure. This demand is about 30% to 50% lower in 2050, compared to 2023 in the 'baseline' scenario. For example, maintaining current student-to-teacher ratios means Moldova would need 13,280 primary and secondary teachers by 2050, compared to 25,994 in 2023 (***Table 1***).

Table 1.
Projected Demand for Childcare and Schooling

Indicator	2023	2030	2040	2050
Baseline (Current Ratios) Scenario				
Child care facilities	774	625	543	530
Kindergartens	687	511	409	406
Early education staff	12,568	9,590	7,886	7,778
Primary schools	87	57	44	42
Secondary schools	1,105	1,034	682	579
Primary & secondary school teachers	25,994	21,696	15,038	13,280

Indicator	2023	2030	2040	2050
Continued Development (Improving Ratios) Scenario				
Child care facilities	774	647	597	616
Kindergartens	687	530	449	472
Early education staff	12,568	9,938	8,665	9,045
Primary schools	87	59	49	49
Secondary schools	1,105	1,071	749	673
Primary & secondary school teachers	25,994	22,483	16,525	15,442

Source: data for 2023 – see source in Data and methods paragraph; data for projected period – author estimations.

By contrast, if Moldova follows the 'continued development' scenario *(Table 1)*, the number of teachers, educational staff, and facilities would still see a reduction, but at a slower pace than the rate of population change, thereby improving the ratios over time.

HEALTH SERVICES

The health of a country is a source of wealth and is essential to building a truly resilient society. Setting up the next generation for long, healthy lives require parents and the education system to encourage health-affirming habits. In a similar spirit, the health system can place greater emphasis on preventive medicine, rather than primarily focusing on treatments once an illness is detected, widely acknowledged as preferable for individual outcomes and state budgets. The relative benefits of preventative medicine are only set to grow as the population ages and chronic lifestyle-related diseases such as cardiovascular disease, cancer, and dementia gain prominence. Currently, Moldova has one of the highest age-standardized premature mortality rates, with cardiovascular diseases a particularly widespread problem (Penina & Raevschi, 2017; Raevschi, Obreja & Penina, 2019). Data on Disability-Adjusted Life Years (DALYs) in 2019 shows that after cardiovascular disease and strokes, liver cirrhosis was the third most common cause of poor health among men, and fourth among women (Raevschi, Obreja & Penina, 2019).

According to the projections, Moldova can expect fewer childbirths and more need for geriatric care in the coming decades. In the 'baseline' scenario (Table 2) the demand for child-focused medical services and infrastructure – maternity ward beds, midwives, and pediatricians – drops by almost 48%. On the other hand, demand for certain medical specialties is set to grow by 16.8%. The NBS reported 66,831 cancer patients in 2022. If the prevalence of this primarily aging-related illness grows proportionally with the population aged 65+, the number of patients would rise to 78,078 by 2050 (in spite of population decline), reinforcing the need for an expansion in the services.

Table 2.
Projected Demand for Health-Related Indicators

Indicator	2022	2030	2040	2050
Baseline Scenario				
Hospital Beds (Total)	16,672	14,283	12,646	11,394
Maternity Ward Beds	710	558	418	375
Geriatric Beds (Therapeutic profile)	748	800	822	874
Geriatricians	29	30	31	33
Doctors (Total)	12,600	10,794	9,557	8,611
Nurses	18,964	16,246	14,384	12,960
Midwives	500	393	294	264
Pediatricians	532	400	295	271
Neuropathologists	358	444	461	487
Pharmacists	1,761	1,509	1,336	1,203

Indicator	2022	2030	2040	2050
				Continued Development Scenario
Hospital Beds (Total)	16,672	14,878	13,896	13,249
Maternity Ward Beds	710	581	459	436
Geriatric Beds (Therapeutic profile)	748	833	903	1,016
Geriatricians	29	32	35	39
Doctors (Total)	12,600	11,244	10,502	10,013
Nurses	18,964	16,923	15,807	15,070
Midwives	500	409	323	307
Pediatricians	532	416	324	315
Neuropathologists	358	462	507	566
Pharmacists	1,761	1,572	1,468	1,399

Source: data for 2023 – see source in Data and methods paragraph; data for projected period – author estimations.

Even if Moldova gradually improves its ratios of health professionals and beds, the 'continued development' scenario suggests the country will need fewer services focused on the general population than today (Table 4). As in neighboring Romania, many Moldovan doctors have been recruited by Western European medical systems, which seek to fill their own shortages. Furthermore, many of Moldova's medical professionals are concentrated at older ages, with 28% of doctors and 18% of nurses at retirement age in 2018 (WHO, 2022). Similar to patterns seen in many countries around the world, including those with high income, Moldova has an older medical labor force in rural settings compared to Chisinau, other cities, or towns.

Nevertheless, for the time being, Moldova has a relatively high number of doctors, well above the minimally recommended standards, slightly below the European average, and near the high-income country average (WHO, 2025). This finding comes from a global database on physicians (of all specializations) to population produced by WHO, which relies on the UN WPP for the base populations. If Moldova's population size is corrected with the National Bureau of Statistics' latest data, the current ratios look even stronger, above the European average.

The multi-dimensional nature of ongoing demographic change means that the concept of aging itself also requires updating. Today's retirees have better health prospects than previous generations, underscoring how chronological age and biological age are distinct concepts (Scherbov & Sanderson, 2020). As longevity increases and functional capacities are maintained into later life, the traditional markers used to define 'old age' become less relevant for policy and planning purposes. This reconceptualization is essential in fostering demographic resilience, as it enables a more nuanced understanding of the potential and needs of ageing populations beyond simplistic age thresholds (Cuaresma et al., 2014a).

Recent data on life expectancy and premature mortality levels indirectly suggest an improvement in the overall health status of the population. Therefore, contrary to common fears, population aging is not (and will not become) the major driver of healthcare spending – instead service delivery models, prices of care, and technology as shown to be the decisive factors (Williams et al., 2019).

SOCIAL PROTECTION

In 2023, 14% of Moldovans fell below the upper-middle income poverty line of US$6.85 per day (2017 PPP), as they were confronted with ongoing jumps in food and energy prices undercutting purchasing power (World Bank, 2025). According to Moldova's national poverty measure, which uses a stricter standard, the share of Moldovans living in poverty reaches around a quarter of the population. Social protection, which aims to alleviate poverty and protect vulnerable groups, will see major shifts in demand over the coming decades, driven by demographic change.

The projections indicate that Moldova will have a growing share of retirees relative to children in the future. As a consequence, spending on social protection in Moldova is expected to further shift in favor of pension benefits compared to parental benefits (the popular 2- and 3-year options) – from about 13:1 (2023) to 21:1 (2050). All else equal, the total value spent on parental leave benefits shows a decline (between -30.6% and -32.2%), while the value of pension benefits increases (+8.5%), shown in Table 3. For pensions, the eligible age threshold is assumed to increase to age 63 (for both men and women) by 2028, according to the current legislation. The eligible retiree population in 2050 is projected to increase by 55k compared to 2023 despite overall population decline, due to population aging and large fluctuations in birth cohorts.

Table 3.
Demand for Social Benefits |
Total public spending in Moldovan Lei (All values = 2023 MDL)

Indicator	2023	2030	2040	2050
Baseline (Constant Ratios) Scenario				
Parental Leave Benefits (2-year option)	11,982,767	9,759,964	8,568,657	8,319,603
Parental Leave Benefits (3-year option)	115,378,744	92,502,365	80,289,118	78,274,700
Pension Benefits	1,664,806,984	1,642,527,015	1,690,253,204	1,807,138,901
Unemployment Benefits	4,138,000	3,639,736	3,126,402	2,581,596
Note: Average per capita benefit in Lei held constant throughout the projection, not adjusted for future inflation				
Further Development (Improving Ratios) Scenario				
Parental Leave Benefits (2-year option)	11,982,767	10,166,629	9,416,106	9,673,957
Parental Leave Benefits (3-year option)	115,378,744	96,356,630	88,229,800	91,017,094
Pension Benefits	1,664,806,984	1,710,965,641	1,857,421,103	2,101,324,303
Unemployment Benefits	4,138,000	3,791,391	3,435,606	3,001,856
Note: Average per capita benefit in Lei increased by 0.5% per year throughout the projection, not adjusted for future inflation				

Source: data for 2023 – see source in Data and methods paragraph; data for projected period – author estimations.

The baseline scenario focuses purely on the implications of demographic change for the social benefit system. However, potential adjustments to the eligibility requirements, for example tying retirement age to life expectancy as done in a growing number of developed countries, would alter the expected demand considerably. Besides alterations to eligibility, the value of benefits themselves can be adjusted – which is the premise behind the 'improving ratios' scenario.

If Moldova expands the value of its future benefits by half a percent per year, the difference in yearly pension costs would require an additional 294 million Moldovan Lei in 2050 (*Table 3*). Similarly, this rate of improvement would mean parental leave benefits (for the 3-year variant) require an extra 1.32 billion Lei in 2050.

In the long-run, stable and effective social benefits depend on human capital investments. A highly educated and skilled population is inevitably tied to general economic development, tax revenues, and reducing reliance on social benefits in the first place. However, Moldova's ongoing human capital flight (brain drain) and emigration-dependent growth have been labelled as a weakness (Augusztin, et. al., 2023), exposing the country to an oversized risk of external economic shocks. Both high rates of emigration and informal work contribute to deceptively low unemployment and lost state investments in human capital. While resolving issues with human capital offers multiple avenues for expanding social benefits, in any future scenario, the costs of social benefits to the national budget will heavily depend on the shifting population size and composition.

PHYSICAL INFRASTRUCTURE & RESOURCE CONSUMPTION

Skyrocketing energy prices gained national attention in recent times, with an estimated 60% of Moldovans living in 'energy poverty', where more than 10% of the household budget goes to covering energy bills UNDP (2023). Such hardships have been brought about by supply constraints and a reliance on imports to meet 80% of the country's needs, but also due to lack of modern energy infrastructure. In addition to energy, this section considers how projected demographic change will influence future resource consumption and demand for physical infrastructure. Unlike the previous sections in this review, total population is used to determine demand due to limited data on usage disaggregated by age, sex, or other characteristics.

In the baseline scenario, where current population-to-resource ratios are held constant, Moldova predictably sees a decline in demand for resources due to the smaller future population (*Table 4*). For example, total energy consumption falls from 2,521 Tons of Oil Equivalent (TOE) in 2022 to 1,723 TOE in 2050.

Table 4.
Demand for Infrastructure & Resource Consumption

Indicator	2022	2030	2040	2050
Constant Ratios Scenario				
Public Transport (buses + minibuses)	21,055	18,038	15,970	14,389
Private Transport (cars + taxis)	745,970	639,074	565,808	509,795
Housing units	1,324,500	1,201,073	1,063,378	958,107
Electricity (millions of kWh)	4,042	3,463	3,066	2,762
Energy consumption (tons of oil equivalent - TOE)	2,521	2,160	1,912	1,723
CO_2 emissions (millions of tons)	5.42	4.64	4.11	3.70
Solid Waste (tons)	53,906	46,182	40,887	36,839
Water supplied to the population by public infrastructure (thous. m^3)	69,929	59,908	53,040	47,789
Wastewater disposal into public sewage system (thousands of cubic meters)	70,939	60,774	53,807	48,480
Improving Ratios Scenario				
Public Transport (buses + minibuses)	21,055	18,789	17,549	16,731
Private Transport (cars + taxis)	745,970	665,702	621,767	592,785
Housing units	1,324,500	1,251,118	1,168,548	1,114,078
Electricity (millions of kWh)	4,042	3,330	2,813	2,423
Energy consumption (tons of oil equivalent - TOE)	2,521	2,077	1,754	1,511
CO_2 emissions (millions of tons)	5.42	4.46	3.77	3.25
Solid Waste (tons)	53,906	44,405	37,511	32,315
Water supplied to the population by public infrastructure (thous. m^3)	69,929	57,604	48,660	41,920
Wastewater disposal into public sewage system (thousands of cubic meters)	70,939	58,436	49,364	42,526

Note: 'Improvement' is defined as greater conservation or reduced usage per capita for the indicators of resource consumption. For the indicators of physical infrastructure (housing and transportation), 'improvement' is defined as a gradual increase in supply to reflect common policy goals.

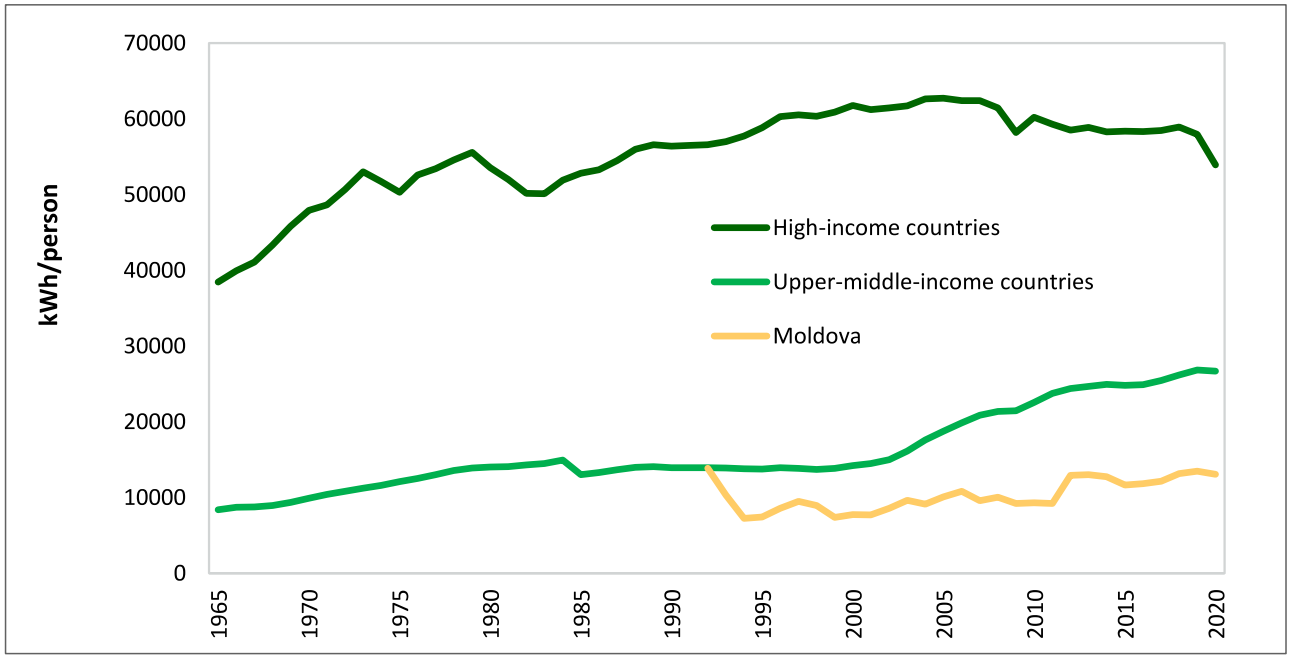
Source: data for 2023 – see source in Data and methods paragraph; data for projected period – author estimations.

Generally, Moldova's smaller population will allow for strategic reductions in physical infrastructure and the resources consumed. However, some infrastructure is more directly tied to population (e.g. electricity) than others (e.g. public transportation), which can have far from a simple 1-to-1 relationship and involve various tipping points that require a critical mass of people in a given locality. Besides potential population-driven reductions, there is also the independent prospect of upgraded technological efficiencies. Table 4 also shows an 'improved ratios' scenario, where the resources consumed, for most indicators, gradually reduce at a rate faster than population decline (-0.5% per year). In this case, for example, the total amount of solid waste produced by Moldova falls from nearly 54k tons in 2022 to 32k tons in 2050 (about 5k tons less than in the baseline scenario).

Although Moldova's population (and therefore number of consumers) is projected to fall, a real possibility exists for a simultaneous rise in per capita consumption. The opposing forces at work may still end with higher total demand for resources. Figure 1 illustrates the observed upward trend in per capita primary energy consumption, and how it compares to Moldova's current and aspirational income group averages, both of which are notably higher. While per capita energy consumption in high-income settings appears on the decline, a holistic view of energy consumption of the population is partially concealed by the import of manufactured goods in the increasingly service-based high-income countries.

Figure 1.

Primary Energy Consumption (per capita)



Source: Our Wold in Data - Energy; Country Profiles

While demographics clearly influence infrastructure and consumption, the opposite is also true. The quality of Moldova's infrastructure is inseparably linked to questions of quality of life, environment, and economy, which in turn have demographic consequences for ability to start families, intentions to emigrate, and other life decisions. Investing in infrastructure can benefit Moldova's human capital, which in turn, puts society in a better position for adaptation to changes in demand for infrastructure and resource use through increased administrative and technological capacities, in line with the broader vision for demographic resilience.

DISCUSSIONS

The findings reveal that demographic decline and aging in Moldova will not affect all public services equally. The steepest declines in demand are projected in education and early childhood care, reflecting low fertility and a shrinking youth cohort. These results support and refine earlier international assessments (e.g., OECD, 2019) by demonstrating how, in Moldova's case, a declining student population can serve as a policy window to improve education quality—assuming strategic resource reallocation.

Conversely, demand for healthcare services is projected to shift rather than decline—decreasing in maternal and pediatric care, while increasing for age-related and chronic disease services. This aligns with international evidence (Williams et al., 2019; WHO, 2022), though our results emphasize Moldova's relatively accelerated shift due to emigration of younger cohorts. Importantly, the study acknowledges that population aging is not the dominant driver of healthcare expenditure growth, highlighting the role of service delivery models and care prices (OECD, 2023).

In social protection, projections indicate a growing imbalance in spending, with pensions increasingly dominating the system. These results diverge slightly from global studies that suggest aging's impact is often overstated (Holzmann et al., 2019). In Moldova's case, the high proportion of informal employment and labor migration creates a more acute challenge for sustainability. Additionally, this study adds empirical weight to concerns about Moldova's generational equity in benefit allocation, showing that under current structures, intergenerational imbalance may worsen.

In terms of infrastructure and resource consumption, both scenarios suggest that population decline will lead to a reduction in overall demand. However, the study emphasizes that per capita consumption may increase, articularly in the case of energy, resulting in total usage patterns that do not necessarily decline in proportion to population. This challenges intuitive assumptions and aligns with regional findings. Other research indicates that in many areas, per capita energy consumption may rise due to changing settlement patterns and higher infrastructure costs. While shrinking populations may reduce aggregate demand, fixed infrastructure and established behavioral patterns can cause total resource use to remain stable—or even increase (ESPON, 2023).

Compared to earlier demographic studies focused primarily on population decline (e.g., UN DESA, 2022), this analysis introduces a more integrated approach that includes implications for fiscal policy, infrastructure planning, and labor market strategy. The present study also extends the demographic resilience framework proposed by UNFPA (2021) by applying it empirically across multiple sectors using Moldova-specific projections.

Unlike macro-level European comparisons that often generalize about Eastern Europe's vulnerability (e.g., OECD, 2019), this review differentiates Moldova's profile by its distinctive migration trends, delayed fertility rebound, improving human capital, and early-stage institutional reforms. This specificity provides a more nuanced understanding of resilience potential.

The study opens several avenues for future research and policymaking. First, integrating population (and human capital) projections with budget simulations could refine fiscal sustainability analyses, particularly for pensions and healthcare. Second, further research should investigate how Moldova's human capital flight interacts with labor market automation, especially in health and education sectors. Third, qualitative studies of household adaptation to shrinking services—especially in rural areas—would help explain behavioral responses to demographic shifts.

Finally, Moldova could benefit from exploring comparative institutional models from countries with similar trajectories, such as Latvia or Estonia, to evaluate which governance structures have effectively absorbed demographic shocks. These comparisons could support the development of a national resilience dashboard—combining demographic, fiscal, and human capital indicators—to monitor and guide adaptive strategies over time.

CONCLUSIONS

This study provides a scenario-based analysis of how Moldova's projected demographic changes to 2050 will reshape sectoral demands in education, healthcare, social protection, and infrastructure. The key conclusions of this study emphasize the need for integrating population projections into sectoral planning. Importantly, the education and childcare systems in Moldova will face a substantial decline in absolute demand due to demographic contraction. This decline offers a strategic opportunity to improve service quality and modernize delivery by optimizing pupil-teacher ratios, among others. At the same time, the healthcare sector is expected to undergo a shift in demand toward chronic and age-related conditions, highlighting the urgent need for health workforce reforms and greater investment in preventive care. In the realm of social protection, the study identifies a growing imbalance, as pension expenditures increasingly dominate public spending. Without comprehensive parametric reforms and stronger contributory mechanisms, the long-term fiscal sustainability of the system may be compromised. Lastly, while overall infrastructure usage and resource consumption are projected to decline in tandem with population size, per capita consumption, especially of energy, may continue to rise. This suggests that population loss does not inherently reduce environmental pressures and calls for careful management of resource efficiency and infrastructure planning.

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REFERENCES

Augusztin, A., Iker, A., Cerovic, D., & Vavra, D. (2023). *Socio-economic Impact on the Moldovan Economy since the War in Ukraine*. Norwegian Refugee Council. Retrieved from https://www.nrc.no/globalassets/pdf/reports/socio-economic-impact-on-the-moldovan-economy/desk-review.pdf

Bloom, D. E., Canning, D., & Fink, G. (2011). *Implications of population aging for economic growth*. Oxford Review of Economic Policy, 26(4), 583–612. https://doi.org/10.1093/oxrep/grq038

Cuaresma, J. C., Lábaj, M., & Pružinský, P. (2014a). Prospective ageing and economic growth in Europe. *The Journal of the Economics of Ageing*, *3*, 50-57. https://doi.org/10.1016/j.jeoa.2014.05.003

Cuaresma, J. C., Lutz, W., & Sanderson, W. (2014b). Is the demographic dividend an education dividend? *Demography*, 51(1), 299–315. https://doi.org/10.1007/s13524-013-0245-x

Cylus, J., & Al Tayara, L. (2021). Health, an ageing labour force, and the economy: Does health moderate the relationship between population age-structure and economic growth? *Social Science & Medicine*, 287, 114353. https://doi.org/10.1016/j.socscimed.2021.114353

Esping-Andersen, G. (1999). *Social foundations of postindustrial economies*. Oxford University Press.

ESPON (2023). *Territorial perspective on green industrialisation: Working paper* (Final version, October 2023). ESPON EGTC. Retrieved from https://www.espon.eu/sites/default/files/publications/files/2024-05/working-paper-green-industrialisation.pdf

Gagauz, O., Pahomii, I., Slav, M., Ştîrba, V., Gailey, N., Samir, K. C. (2024). The population of the Republic of Moldova at the Horizon of 2040. 105 p. https://doi.org/10.36004/nier.2024.go.105.en

Gagauz, O., Tabac, T., & Pahomii, I. (2023). Depopulation in Moldova: The main challenge in the context of extremly high emigration. *Vienna Yearbook of Population Research*, 419-443. https://doi.org/10.1553/p-ke2z-76zz

Grigoraş, E., & Gagauz, O. (2022). Fertility transition from traditional to modern model in Moldova: exploration in base on the "generation and gender survey". *Economy and Sociology*, 100-114. https://doi.org/10.36004/nier.es.2022.1-09

Holzmann, R., Palmer, E., & Robalino, D. (Eds.). (2019). *Nonfinancial defined contribution pension schemes in a changing pension world: Volume 2: Gender, politics, and financial stability*. World Bank. https://hdl.handle.net/10986/12212

Institute for Health Metrics and Evaluation. (2018, October 30). *Learning for life: Higher level of education linked to lower risk of dying* [News release]. https://www.healthdata.org/news-events/newsroom/news-releases/learning-life-higher-level-education-lower-risk-dying

Lee, R., & Mason, A. (2011). *Population aging and the generational economy: A global perspective*. Edward Elgar Publishing. https://doi.org/10.4337/9780857930583

Lutz, W., & KC, S. (2011). Global human capital: Integrating education and population. *Science*, 333(6042), 587–592. https://doi.org/10.1126/science.1206964

Mazzuco, S., & Keilman, N. (2020). Developments in demographic forecasting. *Cham: Springer Nature*. https://doi.org/10.1007/978-3-030-42472-5

OECD. (2019). *OECD economic surveys: Republic of Moldova 2019*. OECD Publishing. https://doi.org/10.1787/eco_surveys-mda-2019-en

OECD (2023). *Education at a Glance 2023: OECD Indicators*. OECD Publishing, Paris. https://doi.org/10.1787/e13bef63-en

Penina, O., & Raevschi, E. (2017). Assessing age-and cause-specific risk groups of premature mortality in the Republic of Moldova. *Bulletin of Semashko National Research Institute of Public Health,* 220-224.

Raevschi, E., Obreja, G., & Penina, O. (2019). Evoluţia mortalităţii premature prin bolile netransmisibile în Republica Moldova: studiu predictiv. In: *Sănătate Publică, Economie şi Management în Medicină 4*(82), 55-61. https://ibn.idsi.md/en/vizualizare_articol/99494/crossref

Scherbov, S., & Sanderson, W. C. (2020). New approaches to the conceptualization and measurement of age and ageing. *S. Mazzuco, N. Keilman (eds.), Developments in Demographic Forecasting, The Springer Series on Demographic Methods and Population Analysis 49*, https://doi.org/10.1007/978-3-030-42472-5_12

Tabac, T. (2021). International migration and population changes in Moldova. *Economy and Sociology*, 94-102. https://doi.org/10.36004/nier.es.2021.2-08

UN DESA. (2022). *World population prospects 2022: Summary of results*. United Nations Department of Economic and Social Affairs, Population Division. https://www.un.org/development/desa/pd/

UN (2024). UN Population Division Data Portal. https://population.un.org/dataportal/home?df=87e675e9-a5fc-4ab3-9163-141b3fed7be5

UNDP (2023). *Energy poverty assessment and support mechanisms in the Republic of Moldova* [Report]. https://www.undp.org/moldova/publications/report-energy-poverty-assessment-and-support-mechanisms-republic-moldova

UNFPA. (2021). *Demographic resilience: Concept and policy implications*. United Nations Population Fund. https://eeca.unfpa.org/en/publications/demographic-resilience

Vanella, P., Deschermeier, P., & Wilke, C. B. (2020). An overview of population projections—methodological concepts, international data availability, and use cases. *Forecasting*, 2(3), 346-363. https://doi.org/10.3390/forecast2030019

Warner, M. E., Zhang, X., & Guillemot, J. (2025). Demographic ageing: an opportunity to rethink economy, society and regions. Cambridge Journal of Regions, Economy and Society, 18(1), 79-92. Pages 79–92, https://doi.org/10.1093/cjres/rsae031

WHO (2021). *World health statistics 2021: Monitoring health for the SDGs*. World Health Organization. https://iris.who.int/bitstream/handle/10665/342703/9789240027053-eng.pdf?sequence=1

WHO (2022). Regional Office for Europe. *Health and care workforce in Europe: Time to act* (WHO/EURO:2022-5732-45048-64235). https://iris.who.int/bitstream/handle/10665/362346/9789289059176-eng.pdf?sequence=1

WHO (2025). The Global Health Observatory

Williams GA, Cylus J, Roubal T, Ong P, Barber S. (2019). Sustainable Health Financing with an Ageing Population: Will population ageing lead to uncontrolled health expenditure growth? European Observatory on Health Systems and Policies, Copenhagen (Denmark); 2019. PMID: 31820890.

Wilson, T., & Rees, P. (2005). Recent developments in population projection methodology: A review. *Population, Space and Place*, 11(5), 337–360. https://doi.org/10.1002/psp.390

Wittgenstein Centre for Demography and Global Human Capital. (2023). *Wittgenstein Centre Data Explorer Version 2.0 (WCDE v2)* [Data set]. https://dataexplorer.wittgensteincentre.org/wcde-v2/

World Bank. (2023). *Moldova Country Economic Memorandum: Resilient Recovery and Reform*. World Bank Group. https://documents.worldbank.org/

World Bank. (2025). *Macro Poverty Outlook for Moldova: April 2025,* https://thedocs.worldbank.org/en/doc/d5f32ef28464d01f195827b7e020a3e8-0500022021/related/mpo-mda.pdf

Authors' contributions

- Conceptualization: Nicholas Gailey, Gagauz Olga, Pahomii Irina
- Methodology: Nicholas Gailey
- Formal analysis: Nicholas Gailey
- Investigation: Gagauz Olga, Pahomii Irina
- Writing – original draft: Nicholas Gailey, Gagauz Olga, Pahomii Irina
- Writing – review & editing: Nicholas Gailey, Gagauz Olga, Pahomii Irina
- Supervision: Gagauz Olga
- Project administration: Gagauz Olga