SAINT LUCIA POLICY ANALYSIS

Saint Lucia's Population Future: Ageing, Migration and the Capacity to Sustain a Nation

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An original analysis of demographic pathways, employment, pension financing and care capacity. Near-term policy focus through 2050, demographic scenarios through 2100, and a conditional comparison to 2150.

The finding

Saint Lucia has no evidence-supported population number below which the nation suddenly becomes unsustainable. Its more immediate risk is a mismatch between the people financing and staffing services and the obligations those services must meet. The strongest signal is rising care pressure, alongside pension financing issues that already require action.

Under the UN benchmark and a fixed census employment profile, maintaining 2026 resources per resident in 2050 would require about 3,900 additional employed people, or an equivalent 4.7% increase in real output per worker. The age-weighted disability proxy grows about 58% over the same period. Economic productivity and hands-on care capacity therefore need separate plans.

All custom pathways are conditional scenarios. They are not probabilities or predictions of national collapse. Monetary values are Eastern Caribbean dollars unless otherwise stated. Charts and original calculations were generated from executed analysis.

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Executive summary

Institutional pressure arrives before any plausible question of an "empty island". The UN World Population Prospects 2024 benchmark, reproduced from age–sex stocks, places Saint Lucia at about 180,500 residents in 2026, 172,100 in 2050 and 108,300 in 2100. The independently reproduced WIC 2023 SSP 2 pathway is higher: 181,700 in 2050 and 146,000 in 2100. These differences argue for decisions that work across futures, not a single collapse date. [D1–D4]

The population's composition matters more than its total alone. With 2022 census age–sex employment rates held constant, benchmark employment falls from about 91,000 in 2026 to 82,900 in 2050. Employed people per 100 residents fall from 50.4 to 48.1. The number aged 65 and over rises from 18,700 to 35,100, and the number aged 80 and over from 3,000 to 8,000. These ages are planning categories, not declarations of dependence.

The resource offset is measurable. To preserve the 2026 employed-to-resident ratio in 2050 requires about 3,900 additional employed people, or 4.7% more real resources per worker than in the fixed-productivity benchmark. Spread over 24 years, that is about 0.19% additional annual growth. Preserving the entire 2026 aggregate employment-based resource base is more demanding: 9.8%, or 0.39% a year. Neither result guarantees sufficient tax receipts, pension contributions or quality of care.

Care is the sharper near-term constraint. Applying local census disability proportions to the age distribution gives a 57.5% increase in the planning proxy by 2050, and a 72.9% increase per employed person. A chosen 25% warning threshold is reached around 2037 in the benchmark and between 2036 and 2038 across the five demographic scenarios. A national register of care hours, severity and staffed posts is needed to convert this into actual staffing requirements.

Pension financing cannot be reduced to an age ratio. The January 2026 IMF report repeats a legacy no-reform total-income shortfall around 2035 and reserve exhaustion around 2051. Those dates are external scenarios, not a new current-law valuation. The reported 2080 outcome depends on proposed reforms whose enactment was not verified. The first pension priority is a published current-law actuarial update and recent audited accounts. [P1–P9]

The most useful immediate package combines employment support with childcare and respite care, retention of essential professionals, transparent pension adjustment and a funded care workforce plan. Fertility recovery affects the workforce slowly and raises child-support needs first. In the illustrative combined programme, starting in 2026 rather than 2036 adds about 106,000 employed-person-years cumulatively through 2050. This is scenario arithmetic, not an estimated causal programme effect.

The baseline has more than one answer

The starting chart compares CSO midyear estimates for 2011 and 2023. Children under 15 fell from 37,783 to 31,852, while residents aged 65 and over rose from 14,558 to 19,763. These are changes of −15.7% and +35.8%, respectively. The chart describes two endpoints in one estimates series; it is neither a census comparison nor a forecast. [B1–B2]

Source and reference date	People	Definition and treatment
CSO midyear age table, 2011	167,366	National estimate; age groups sum to total.
CSO midyear age table, 2022	183,251	Annual estimate vintage used in the 2011–2023 series.
CSO census night, 12–13 March 2022	172,948	Usual residents: 171,834 in households plus 1,114 in institutions. Excludes 5,859 visitors.
CSO midyear age table, 2023	184,100	Same annual estimates series as the chart.
Economic and Social Review, 2025	185,410	Preliminary resident estimate; 2024 revised to 184,821.
UN WPP 2024, July 2026	180,488	Indicator total. Model age–sex sum is 180,510;22-person rounding difference.

The census is itself adjusted, rather than a simple raw enumeration. Release 2 reports a weighted national undercount of 23.3% and an adjustment factor of 1.304, using mapping and listing information rather than a post-enumeration survey. Its overview quotes an older 2022 annual estimate of 182,289, different from 183,251 in the later age table. These facts limit the precision of apparent cross-source gaps. [B3]

The roughly ten-thousand-person census–annual-estimate gap cannot be read as measured emigration. Reference dates differ, adjustment methods differ, and estimates may carry forward earlier population errors. A credible reconciliation needs CSO's age-specific rebasing and documentation of births, deaths and migration. Multiplying every UN age group by one census-to-UN ratio would assume that all age groups were mismeasured equally; this study does not do that.

The primary projection therefore retains the UN's own age–sex stocks and demographic assumptions. Census age–sex employment and disability proportions enter only as explicitly separate behavioural overlays. The independently constructed IIASA series is an alternative demographic baseline. The estimated bridge to 2026 is the UN projection itself, not an observed 2026 census.

Fertility migration and population momentum

Below-replacement fertility is supported by both local and international evidence. The Ministry of Health reports 1,326 births and a total fertility rate of 1.06 children per woman in 2025, compared with 1.54 in 2016. In the UN modelled historical series, fertility remains below 2.1 from 2002 onward. The net reproduction rate, which also accounts for daughters' survival, is below one in recent years. Replacement is not exactly 2.1 in every setting. [B4, D1]

Indicator	UN 2026	UN 2050	Interpretation
Fertility, births per woman	1.37	1.42	Benchmark assumes a modest recovery, not replacement.
Births, people per year	1,959	1,382	Depends on fertility rates and number/ages of women.
Deaths, people per year	1,611	2,268	Ageing can raise deaths despite improving survival.
Natural change, people per year	+348	−886	Births less deaths within this same UN series.
Net migration, people per year	−49	−50	UN assumption/estimate, not a complete border-flow count.
Life expectancy, male / female	69.7 / 76.7	73.5 / 80.0	UN scenario years, not healthy-life expectancy.

UN estimates show negative natural change in the pandemic year 2021, followed by positive values; sustained negative natural change begins in its projection in 2033. The latest matched local birth-and-death totals needed to verify sustained natural decrease were not located. Local registered births and UN modelled births differ materially, so subtracting UN deaths from local births would create a false measurement. [B4, D1]

UN estimates imply net outflow in much of 1990–2023, averaging roughly 346 people a year, with zero values in some recent years. These historical estimates are uncertain and do not establish present gross movements. Census household reports identify 3,236 intercensus emigrants, but whole households that left cannot report themselves. A residual population estimate also absorbs errors in counts and registration. [B3, D1]

Fewer births can result from lower fertility at each age, fewer women reaching those ages, or both. Population momentum means that past small cohorts affect births and labour supply for decades. Even a return to replacement fertility would not instantly restore a balanced age structure; the new children would first need care and education, and only later enter employment.

What existing research already establishes

Evidence	Horizon or scope	Use and limitation
CSO census and annual series [B2–B3]	Observed or adjusted historical stocks	Best local age, household and labour detail; baseline reconciliation remains unresolved.
UN WPP 2024 [D1–D2]	1950–2100	Common annual age–sex framework; Saint Lucia inputs do not incorporate the 2022 census as a census benchmark.
WIC 2023 V 15 and SSP 2300 V 02 [D3–D4]	2020–2300	Alternative education, fertility and migration paths; post-2100 rules are imposed, not probabilities.
NIC, ILO and IMF [P1–P10]	Multi-decade pension projections	Already identify financing pressures; public vintage and current-law gaps prevent an independent actuarial replication.
Moonie 2013 [L1]	Households, 2015–2030	Local precedent for separating people from households; permits a limited old-vintage check.
ECLAC/PAHO, UN NTTA [L2–L3]	Economic transfers and unpaid time	Explain why age dependency differs from actual support; no local monetary/time profiles imported as facts.
OECD Employment Outlook 2025 [L4]	Comparative ageing and employment	Useful mechanisms for employment, skills and technology; OECD elasticities are not Saint Lucian estimates.

The research gap is an institutional translation: how much additional employment, productivity or care capacity would preserve specified standards under a coherent population pathway? Long projections already exist. Extending a curve beyond 2100 is not, by itself, an original contribution.

This study contributes executed offsets, transparent warning thresholds, one-at-a-time sensitivities and an early-versus-delayed implementation comparison. It also checks a published 2013 household projection against the later provisional census. It does not present a new actuarial valuation, a causal estimate of family-policy effects, or a probability of national collapse.

Economic support is measured as employed people per resident. A National Transfer Accounts support ratio would weight people by age-specific labour income and consumption. Those compatible Saint Lucian profiles were not available, so using the NTA label would imply information the calculation does not contain. Unpaid care is considered explicitly, but its monetary value is not imputed. [L2–L3]

One demographic framework and five pathways

The benchmark is the UN's annual 1 July age–sex population, with 2026 as the projected starting year. Custom scenarios use a calibrated annual cohort-transition model: each cohort ages with the UN's implied transition ratio, fertility changes scale new entrants, and additional net migration is allocated to ages 20–39. This is a transparent sensitivity around the official trajectory, not an independently fitted population forecast. The appendix gives the equations and code.

Pathway	Fertility assumption	Incremental migration
Benchmark	UN medium: about 1.37 in 2026,1.42 in 2050 and 1.50 in 2100.	None beyond the UN trajectory.
Low fertility and outflow	Schedule scaled toward approximate TFR 1.15 over 10 years; held thereafter.	−2 per 1,000 residents/year, phased over 5 years.
Retention and return	UN medium fertility schedule.	+2 per 1,000 residents/year, phased over 5 years.
Fertility recovery	Schedule scaled toward approximate TFR 1.80 over 15 years; held thereafter.	None beyond the UN trajectory.
Combined adaptation	Same fertility recovery.	Same positive migration increment.

All pathways inherit the benchmark's survival and net cohort-transition pattern. Migration increments are half female and half male, uniform across ages 20–39, and depend on the scenario's current population rather than a permanent absolute outflow. Arrivals age and their children enter subsequent cohorts. The exercise does not model gross flows, selection by occupation, different migrant fertility or return migrants' actual age profile.

The adverse fertility level is informed by the recent local rate of 1.06; the recovery level resembles the UN's estimated rate in the mid-2000 s. Neither is a policy-effect estimate. The migration increment is initially of the order of 360 people a year once phased in, similar in scale to the uncertain historical UN average net outflow. Positive retention of that size remains an illustrative target requiring housing, employment and service capacity.

Employment rates come from detailed 2022 census Table 10.10, separately for men and women. This is not a current employment forecast: the latest labour-force survey reports 99,528 employed in Q2 2026, compared with the model's 90,965 using a frozen historical profile. Different reference periods, survey weights, recovery and population baselines prevent a silent splice. The model isolates demographic composition. [B3, B6]

Population and institutional pressure move differently

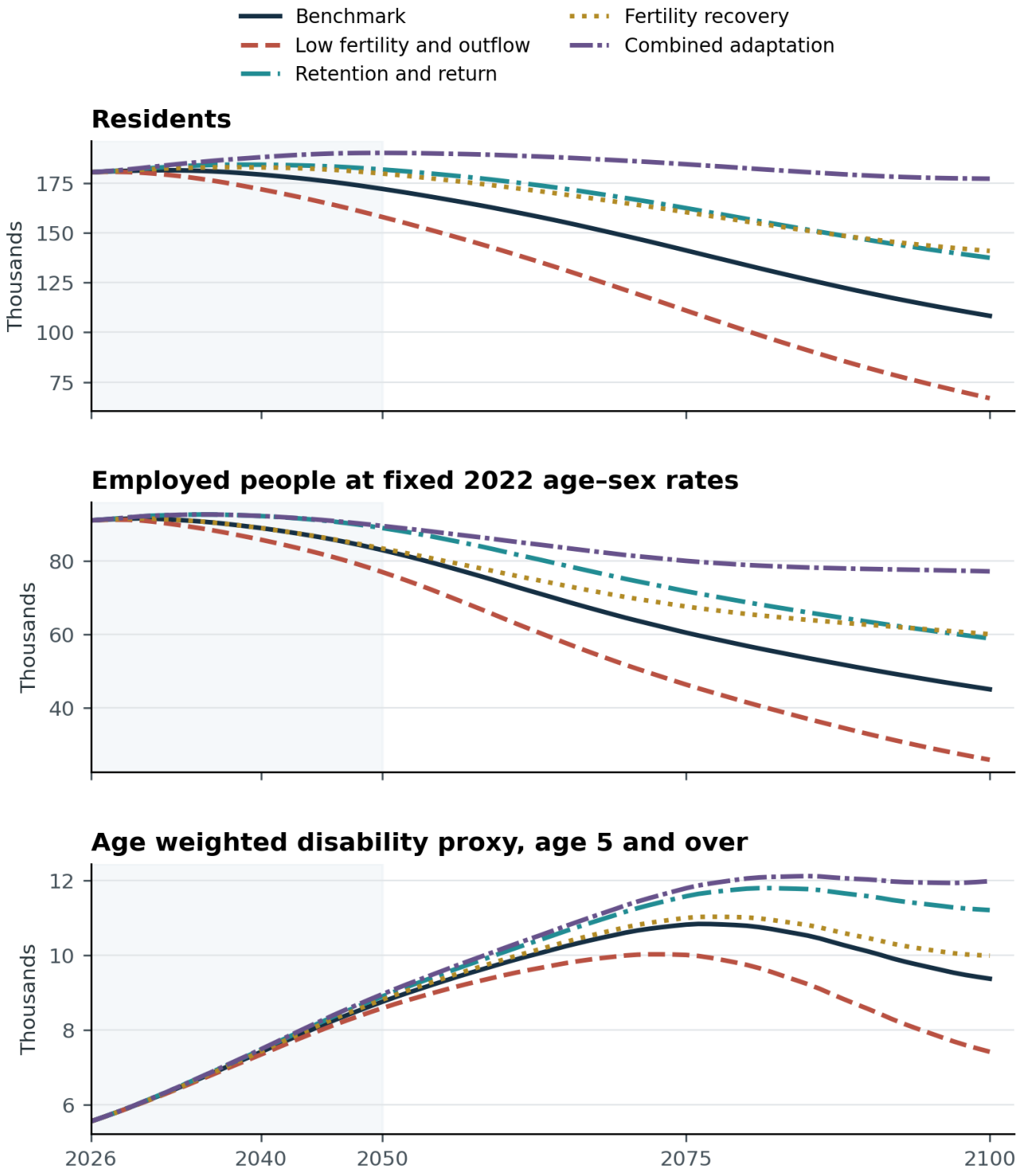


Figure 1. Reproduced UN benchmark and custom cohort-transition scenarios, 2026–2100. Employment holds 2022 census age–sex rates constant; disability is an age-weighted census proxy, not diagnosed care need. Shading marks the main policy horizon to 2050. All lines are projections or conditional calculations, not observations or confidence intervals.

The age structure changes well before 2100

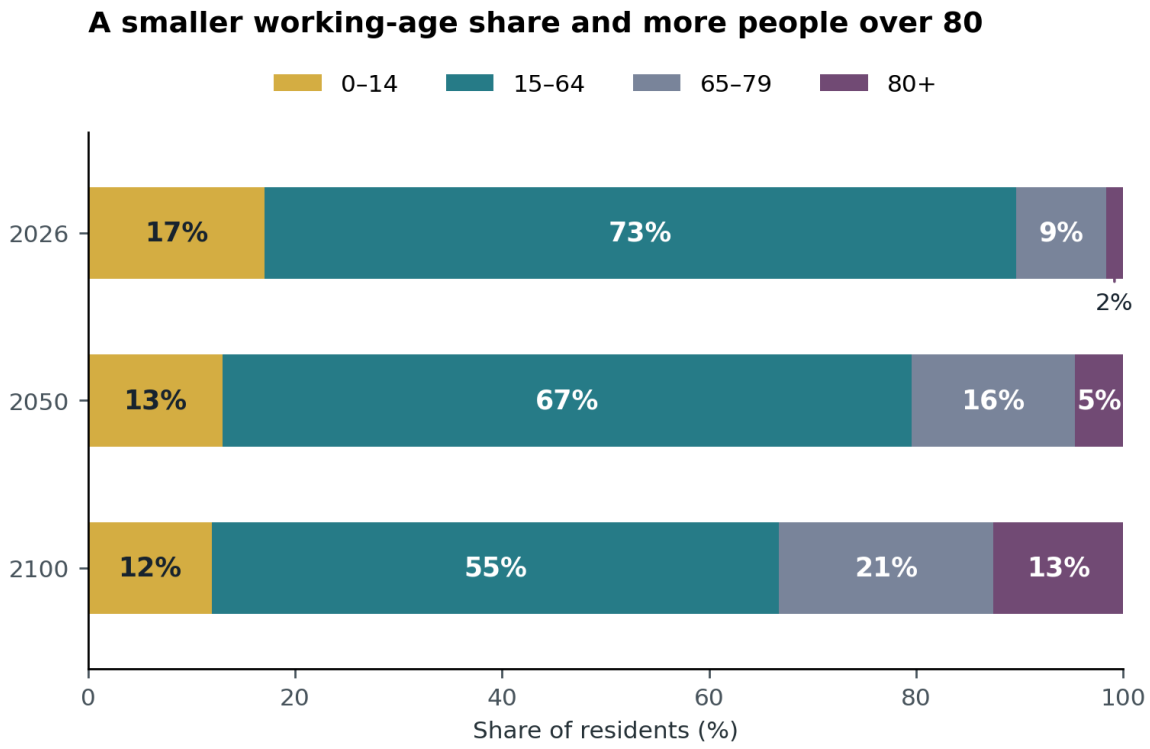


Figure 2. UN benchmark age shares, calculated from single-year male and female stocks. Age groups describe population composition; they do not identify who works or receives support.

Year	Residents thousands	Employed thousands	Age 65+ thousands	Age 80+ thousands	Employed per 100
2026	180.5	91.0	18.7	3.0	50.4
2030	181.4	91.5	22.0	3.3	50.5
2040	179.3	88.9	29.5	5.1	49.6
2050	172.1	82.9	35.1	8.0	48.1
2075	141.2	60.4	44.6	14.3	42.8
2100	108.3	45.0	36.0	13.5	41.6

The conventional old-age ratio increases from 14.3 people aged 65+ per 100 people aged 15–64 in 2026 to 30.7 in 2050 and 60.6 in 2100. Total age dependency, including children, rises from 37.8 to 50.2 and 82.4. These ratios do not count actual workers, contribution months, earnings or unpaid care. Older residents can remain workers, carers, donors and providers of family support.

Higher fertility raises the number of children quickly, but contributes little to employment before 2050. This can make employed people per resident look worse during the transition even when future workforce renewal improves. Conversely, low fertility can temporarily improve this ratio by reducing child numbers. A single support ratio should therefore never be the sole policy objective.

What would it take to maintain resources

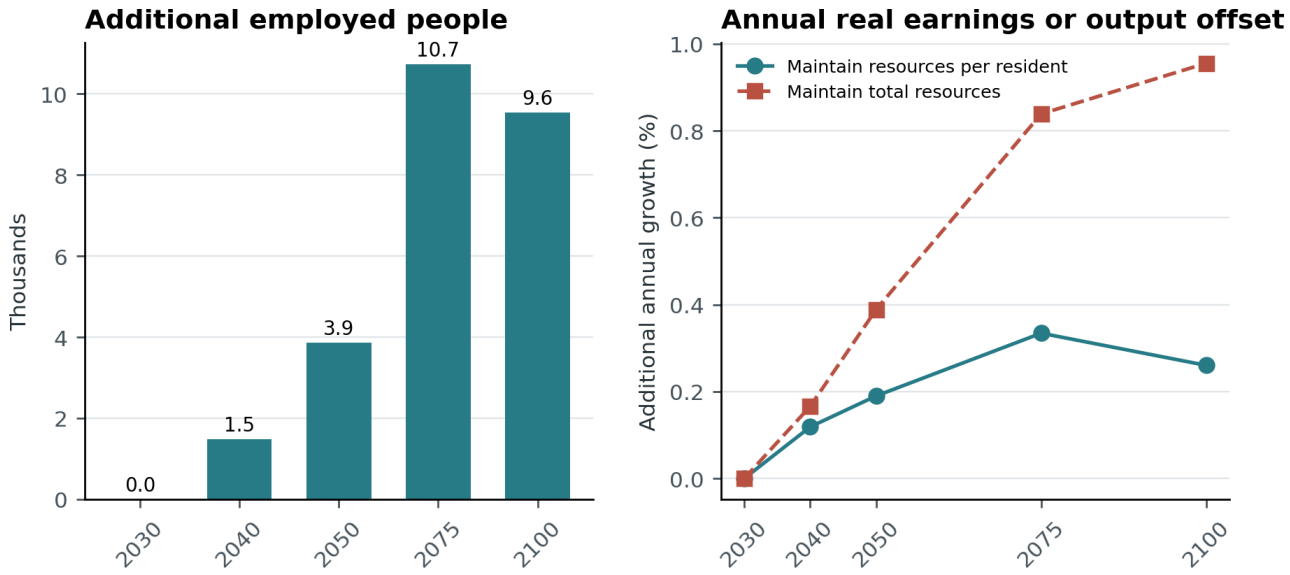


Figure 3. Original offsets relative to 2026, using the UN benchmark and fixed employment rates. Extra workers and additional real output per worker are alternative arithmetic offsets. The right panel separates per-resident resources from maintaining the 2026 aggregate resource base.

By 2050, preserving 2026 resources per resident requires 3,863 additional employed people, holding output per worker constant. Alternatively, a 4.66% increase in output per worker fills the same arithmetic gap, equivalent to 0.19% additional annual growth from 2026. Preserving total employment-based capacity needs 9.76%, or 0.39% a year. The per-resident target preserves a starting ratio; it does not demonstrate that today's provision is adequate.

In the migration-only improvement scenario, 2050 employment is about 6,000 higher than the benchmark and population about 9,800 higher. The remaining employment gap to preserve the starting support ratio is about 2,800. Under fertility recovery alone, that gap is about 7,300 because children arrive before most additional workers. A combined demographic pathway still needs employment or productivity adaptation.

A five-percentage-point rise in employment at ages 25–64 adds about 4,800 workers to the 2050 benchmark, enough to close its per-resident gap. This is demanding: it requires sustained jobs, matching skills and replacement childcare or elder care. It is not equivalent to reducing unemployment by five points, since unemployment uses the labour force as its denominator.

No precise additional NIC-contributor requirement is estimated without contributor months and pensioner profiles. Conditional on full-year contribution eligibility, each one-percentage-point increase in coverage of modelled 2050 employment would represent about 829 contributors. Receipts would then depend on insurable earnings and compliance, while future entitlements would also rise.

Employment and productivity have different channels

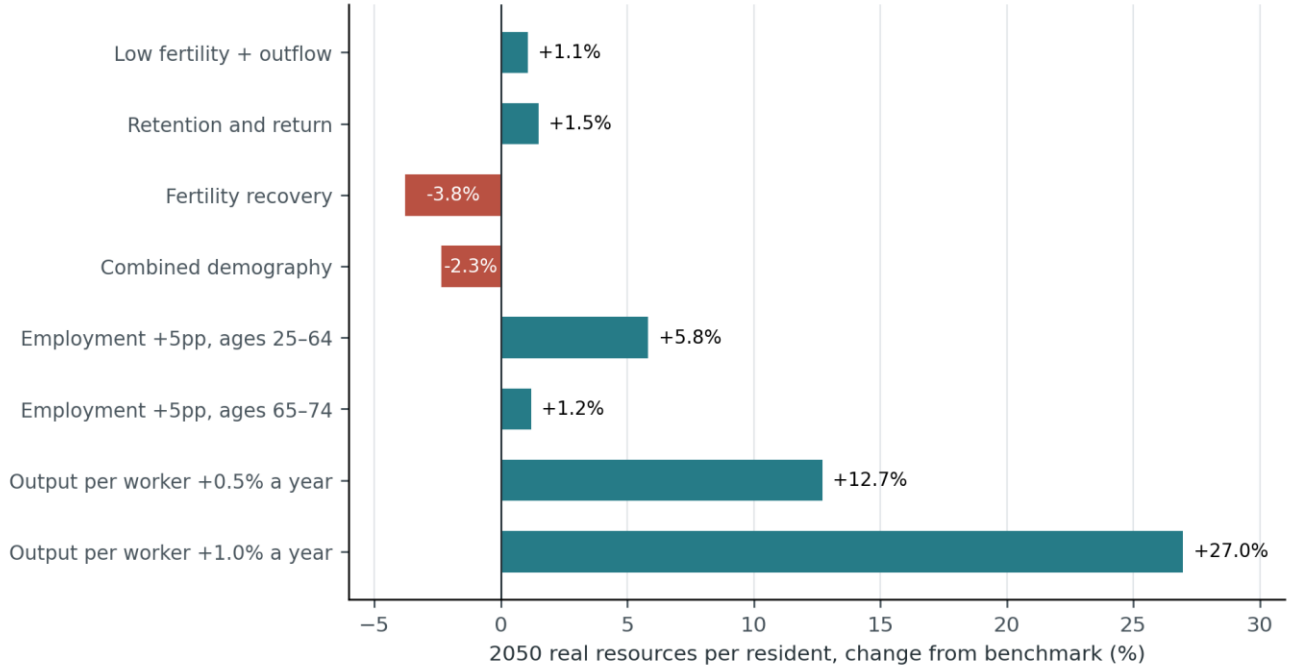


Figure 4. One-at-a-time 2050 sensitivities relative to the benchmark, calculated from executed scenarios. Employment changes are percentage-point changes in age-specific employment rates. Productivity changes compound from 2026. These are deterministic assumptions, not causal effect sizes or uncertainty intervals.

An additional 0.5% annual output-per-worker improvement produces 12.7% more resources per resident by 2050 than the fixed-productivity benchmark. A 1% sensitivity gives 27.0%. These totals show arithmetic scope, not evidence that a particular technology will deliver it. Earnings, taxable income and service output may respond differently.

The model permits positive and negative effects to be combined transparently. Adding five points to employment rates at ages 25–64 and 0.5% annual real productivity growth raises 2050 resources per resident about 19.3% relative to the benchmark. That would exceed the 4.7% demographic offset if achieved. It does not settle pension balance because benefit formulas and care wages may also rise.

The old-age employment sensitivity is smaller: five percentage points at ages 65–74 raises the 2050 resource measure about 1.2%. Flexible work and age-friendly jobs can help, but should complement disability protection and realistic occupational requirements. OECD evidence supports examining participation, training and technology together; its estimated effects cannot be transferred directly to Saint Lucia. [L4]

Starting earlier changes the accumulated workforce

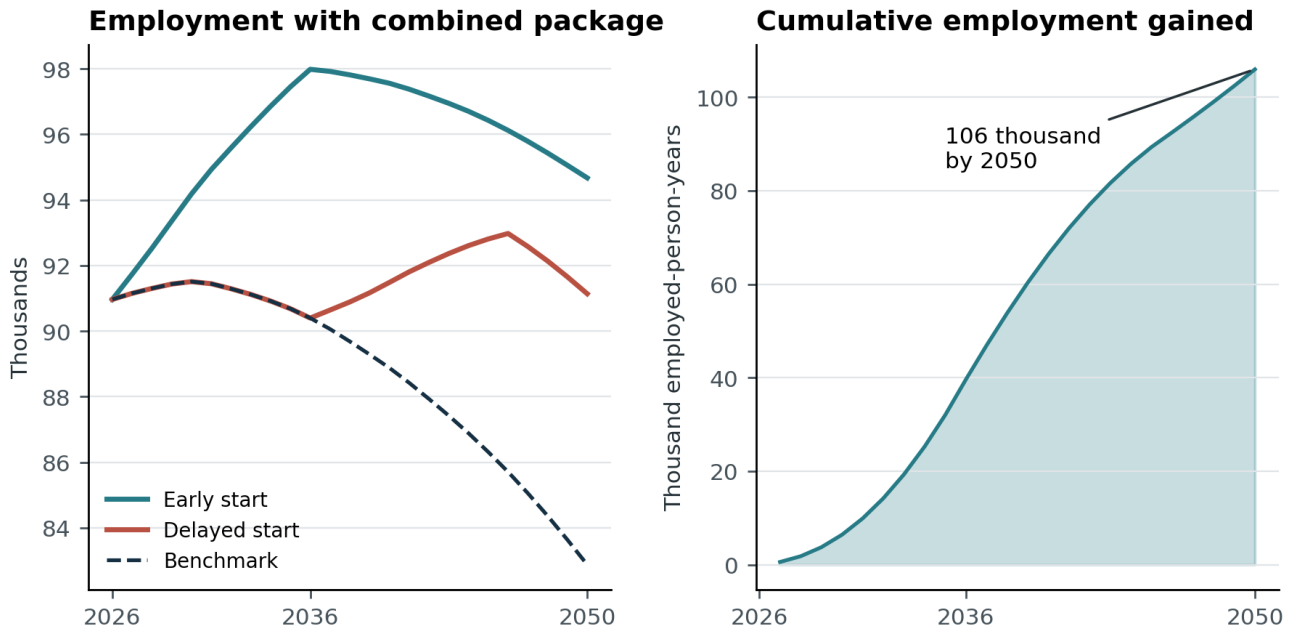


Figure 5. Combined demographic adaptation plus a five-point employment-rate rise at ages 25–64. Early start is 2026; delayed start is 2036. Employment phases over ten years, migration over five, fertility over fifteen. The cumulative difference sums annual employed-person equivalents; it is not discounted GDP or a programme return.

The early package yields about 94,700 employed people in 2050, compared with 91,100 under delayed implementation and 82,900 in the benchmark. The early–delayed difference accumulated over 2027–2050 is about 106,000 employed-person-years. It reflects the assumed timing of successful changes, not a claim that the required programmes already exist or will certainly work.

The delayed pathway can temporarily have a higher employed-to-resident ratio because fewer additional children have yet arrived. Early action nevertheless provides more total workers and earlier years of potential contributions. This distinction is why the timing comparison reports both cumulative employment and population, rather than choosing the most favourable-looking ratio.

Care-workforce timing has a concrete constraint: SALCC's nursing degree takes four years. Retention and qualified return placements can affect staffing sooner, while expanding training requires tutors, clinical placements, registration and funded jobs. Family policy has a longer lag: additional births cannot immediately replenish contributors. [H1–H1a]

Care capacity requires its own standard

The census reports some disability among 8.4% of people aged 65–69, 18.7% at 75–79 and 37.7% at 85–89. Applying those age-specific proportions to the UN benchmark creates an age-composition planning proxy. It increases from 5,557 in 2026 to 8,755 in 2050. These are weighted equivalents, not a count of assessed clients or a prediction of clinical disability. Under-fives are excluded because a compatible rate was unavailable. [B3]

2050 care sensitivity	Capacity units needed per 100 in 2026	Care proxy per employed person 2026=100
Fixed census prevalence	157.5	172.9
Prevalence 20% lower at every included age	126.0	138.3
Fixed prevalence, employment+5 pp at 25–64	157.5	163.4

If each unit of the proxy required unchanged care hours and staff productivity, maintaining current provision would require about 58% more care capacity by 2050. For every 100 relevant staffed units today, the scenario implies roughly 158. This normalized calculation is useful for scale, but it cannot be turned into a national number of nurses without current hours, care severity, workforce mix and unmet-need data. Preserving current provision may preserve current shortages.

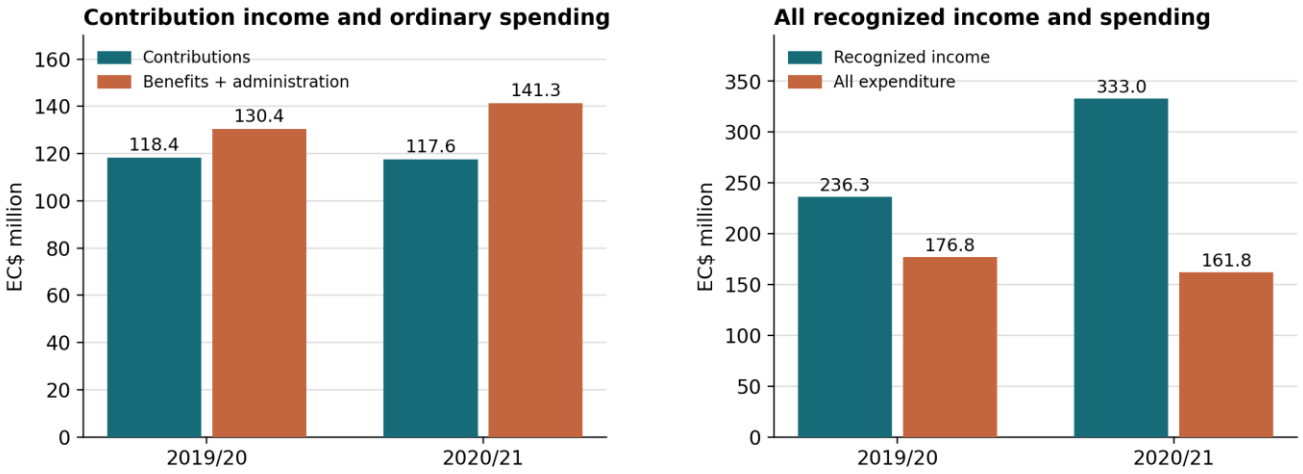
A twenty-percent reduction in age-specific prevalence reduces the requirement to roughly 126 units. This is an illustrative healthy-ageing sensitivity; no local causal evidence establishes how to achieve it. It also does not imply that people with disabilities need the same services, or that all care needs are captured by this census question.

An official September 2025 statement reported a nursing shortfall exceeding 100. PAHO's workforce profile published in 2025 uses professional counts from 2017, so those counts cannot establish today's available staff. Filled posts, full-time-equivalent hours, skills, location and retention are the necessary capacity measures. [H1–H2]

Paid work and family support interact. More employment can reduce unpaid care time; higher care wages can improve retention while increasing service costs. Older residents themselves provide childcare and family support. A proper time-use survey is needed to measure these flows: a census household-activity column cannot be treated as a complete unpaid-care account. [L3]

Pensions need both cash flow and adequate benefits

Pension pressure is already visible in historical accounts. The audited FY 2020/21 consolidated figures show EC$117.6 million of contributions against EC$141.3 million of ordinary benefits and administration. Our recalculation gives 83.2% contribution coverage and an EC$23.7 million gap. Recognized total income was nevertheless EC$333.0 million, compared with EC$161.8 million of expenditure including emergency relief, finance costs and tax. The accounting surplus was EC$171.2 million. These measures answer different questions. [P2; calculations]



Source: NIC audited consolidated accounts, FY2020/21, pp17–20. Calculations: SLPA.
Recognized income includes valuation gains; all spending includes pandemic relief. Historical figures are not a 2026 balance.

Figure 6. Historical NIC accounting, EC$ million. Original calculations from audited consolidated statements. Investment and other recognized income include items that are not immediately available cash. The pandemic-year accounts are not a 2026 financial assessment.

The latest audited report located on NIC's documents page covers the year ending 30 June 2021. Its financial statements were authorized on 13 March 2025. The authorization date does not update the balance sheet. Consolidated reserves of EC$2.440 billion include subsidiary and other accounting interests; the ratio to that year's total expenditure is 15.1. This is not fifteen guaranteed years of pension payments. Asset liquidity, future receipts, new liabilities and investment losses all matter. [P2]

Published pension dates require a vintage label

Question	Evidence and status
When do contributions fall short?	Already occurred in retrieved FY 2019/20 and FY 2020/21 accounts after ordinary administration. Current-year status is not established.
When does total income fall short?	Around 2035 in the legacy no-reform scenario repeated by IMF in January 2026. External projection, not a new result.
When are reserves exhausted?	2051 in that published scenario; 2080 under the proposed package reported in Annex VII. Neither is independently verified here as a current-law result.
Will pension payments stop then?	Reserve exhaustion would require financing or benefit/rule adjustments; contributions need not stop. It is not a national-collapse date.

The current NIC website lists a 5% employee contribution and 5% employer contribution, a monthly insurable ceiling of EC$5,000, and normal pension eligibility at age 65 with at least 180 contribution months. The published formula starts at 40% of best-five-year pensionable earnings, with an increment for additional contribution months. Early-retirement provisions in the retrieved consolidation allow retirement from 60 with a reduction. [P3–P6]

The minimum pension increased from EC$300 to EC$500 in August 2024. Government reports a further 3.9% increase applying to NIC pensioners from July 2025, including those affected by the earlier minimum increase. NIC's benefit webpage still displays EC$500; that webpage alone should not be used to infer the exact current minimum. Government public-service pensions are a separate scheme. [P4, P7]

The retrieved January 2025 amendment concerns payment methods, assistance and forms; it does not enact the proposed contribution or retirement-age package. ILO records indicate that the valuation as at June 2020 was submitted in April 2024, but the full report was not retrieved. The January 2026 IMF discussion and the older NIC valuation summary do not supply enough consistent inputs to rebuild it. [P1, P5, P8–P9]

A limited accounting illustration is possible. At an assumed uniform 10% rate, FY 2020/21 receipts imply EC$1.176 billion of assessable earnings. One extra percentage point on that unchanged base yields EC$11.76 million. Covering that year's ordinary expenditure alone implies 12.01%. This is not a recommended rate or an actuarially sufficient rate: it holds behaviour and the earnings base fixed and excludes future entitlements. It must not be extrapolated as a 2026 reform costing. [P2; calculations]

More households can coexist with slow population growth

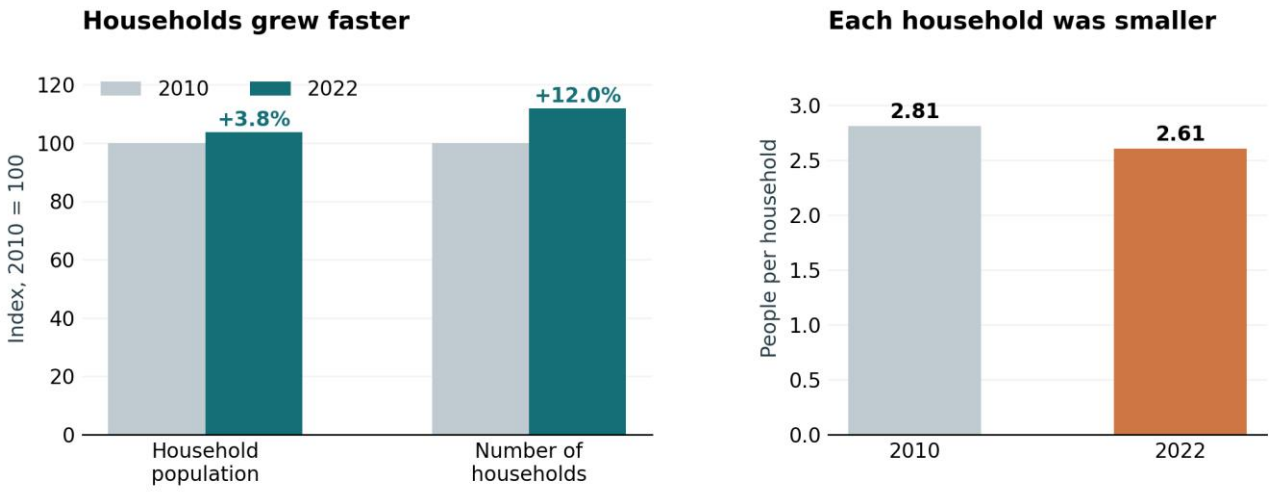


Figure 7. Census household measures. Calculations use usual household population and private households, excluding institutional residents. The provisional weighted 2022 census remains subject to measurement uncertainty. [B3]

Between 2010 and 2022, household population grew 3.8%, while household numbers rose 12.0%. The calculated mean fell from 2.812 to 2.605 people per household. In 2022, 32.0% of households contained one person; 27.0% of people aged 65 and over in households lived alone. These results support planning for smaller, accessible homes and nearby services. They do not show that each older person living alone needs formal care. [B3; calculations]

Moonie's 2013 household projections offer a genuine earlier-vintage check. Linear interpolation between its 2020 and 2025 outputs gives 2022 household counts of 63,112, 65,072 and 65,438 under constant, linear and exponential membership assumptions. Compared with 65,951 in the provisional census, the differences are −4.3%, −1.3% and −0.8%. This is a limited check: 2022 was not an original projection year, dates are not perfectly aligned, and census adjustment error remains. It supports the mechanism of smaller households, not a claim that one method is validated for future decades. [L1]

Housing demand also depends on location, household income, inheritance, diaspora purchases, tourism use and the condition of vacant dwellings. A vacant house far from jobs is not a substitute for an affordable accessible home near care. The 2025 Economic and Social Review reports bank credit for house purchases rising to EC$444.1 million, while residential construction and renovation credit slipped to EC$458.8 million. Different market segments already move differently. [B5]

Blood schools and disruption

Blood supply is an operational system

Official appeals document a blood shortage in December 2024 and subsequent recruitment efforts. The Health Ministry also reports pressure from trauma and road accidents. These observations establish service pressure, not a demographic cause. Residents within a donor-age band are not automatically medically eligible donors. Actual supply depends on donor participation, accepted donation frequency, screening, usable yield, expiry and blood-type matching. [H3, B4]

No compatible national series of usable collections, medical deferrals, transfusion requests and unmet demand was retrieved. A demographic blood-insufficiency year is therefore not estimable. The blood service should track days below its clinical inventory minimum and requests not filled by component and type. Better donor recall and reduced wastage may help even as population falls; general productivity growth cannot manufacture blood.

Smaller schools still need skilled teachers and access

Public primary enrolment fell 3.3% to 13,280 in 2024/25. Teacher numbers increased to 1,039, but the number of trained teachers fell 7.8% to 730. Falling cohorts therefore do not automatically resolve skill shortages. Public secondary enrolment also fell, to 10,097. [B5]

School-level decisions require cohort trends, trained-teacher availability, travel time, road resilience and learning results. The current evidence does not support a universal minimum enrolment for closure. Shared specialists or redeployment may improve teaching while preserving access. Local migration could reverse a national pattern in individual districts; no elaborate district forecast is made here.

One bounded disaster stress

Hurricane Tomas demonstrates the exposure of roads, schools and health facilities. A World Bank evaluation reports US$336.2 million of damage and losses; this is not an equivalent fall in GDP or a government cash bill. The study applies one separate illustrative employment-capacity shock in 2030: −5% that year, −3% in 2031 and −1% in 2032, recovering by 2033. The magnitude is not calibrated as Tomas's causal effect. [H4]

Executed against the demographic benchmark, the shock removes about 8,232 employed-person-years over three years. No extra migration or fertility shock is added, avoiding double counting. Reconstruction spending is an additional fiscal exposure requiring a project-specific estimate; the historic damage figure is not added mechanically to NIC or Treasury deficits. A funded continuity plan for care, transport and benefit payments is useful across demographic futures.

National systems can adapt at different speeds

Credit and public assets

Population decline can affect loan demand, property turnover and collateral recovery. Older borrowers may draw down savings, while pension funds may need to sell assets to meet benefit payments. If those assets are concentrated in domestic property or government debt, many institutions can become exposed to the same shock. These are channels to stress-test, not predicted price falls.

Saint Lucia participates in a regional currency and financial system. Mortgage pricing also reflects bank funding, capital, credit risk, competition, the EC dollar framework and international conditions. The 2025 Economic and Social Review reports a 6.39% weighted average bank lending rate; it is not a mortgage-specific rate. No defensible equation maps a national population count directly to an interest rate. [B5]

Small countries and shared services

Dominica and Saint Kitts and Nevis illustrate that a smaller population can maintain sovereign institutions while sharing currency, judicial and other services regionally. [R1–R2] Their existence is not evidence of a transferable minimum viable population. The relevant comparison is how service costs and specialist capacity are shared, not simply how many people live there.

A smaller population can reduce pressure on land, congestion and some infrastructure. Falling school cohorts may allow more attention per pupil if teaching resources and access are maintained. Aggregate GDP can decline while income per person rises. Conversely, a national average can improve while a remote community loses its nurse or bus service. Fiscal and service planning must therefore track distribution, travel time and staffing as well as totals.

Fixed costs need an explicit service decision

Preserving output per resident is less demanding than preserving every existing institution at its present scale when population falls. Some costs vary with users; others, such as a specialist team, laboratory or secure information system, have a minimum operating scale. The employment analysis reports both per-resident offsets and a separate fixed aggregate-capacity sensitivity. Neither calculation measures the actual fixed-cost share of Saint Lucia's budget.

Regional procurement, shared specialist rosters, referral agreements and interoperable records can spread fixed costs. These arrangements need enforceable service standards and transport capacity. Closing a local facility may save its operating budget while shifting costs to households through longer journeys and unpaid time. Such transfers must appear in the decision, rather than being counted as pure savings.

Thresholds identify decisions rather than collapse

Thresholds were defined as monitoring rules before interpreting scenario results. They are deliberately separate: a financial obligation has a different meaning from a planning warning. Dates below are approximate scenario crossings, not precise forecasts. Counts of years use annual model points, including the first crossed year.

Measure and rule	Rationale	Result and status
Employment support: E/P below 95% of 2026	Warning of a 5% loss in the employment share; no statutory meaning.	Benchmark 2052; five scenarios 2044–2056. None is a national viability limit.
Care load: (D/E)/(D 0/E 0)≥1.25	Chosen 25% capacity-planning trigger; D is disability proxy.	Crossed 2036–2038; benchmark 2037, 14 annual observations through 2050.
Old-age ratio: N 65+/N 15–64≥0.30	Descriptive cohort milestone, not actual dependence.	Benchmark 2050; scenarios 2047–2054.
NIC ordinary balance: C−B−A<0	Contributions do not cover ordinary benefits and administration.	Already crossed in retrieved 2019/20 and 2020/21 accounts. Current status not established.
NIC total income balance<0; reserves=0	Cash-flow and stock thresholds with different financing consequences.	External legacy 2035/2051 scenarios; new current-law date not estimable.
Care staffing, blood inventory, school access	Locally defined clinical or access standard.	National demographic crossing not estimable without need, staffing and service data.
Minimum population to sustain the nation	No specified cost, service or financing standard.	Not estimable; no defensible universal population floor.

Changing the care warning to a 10% increase moves the benchmark crossing to 2031; a 50% increase moves it to 2044. Across demographic scenarios those windows are 2031–2032 and 2043–2046. The choice of warning level changes the date without changing the underlying pressure. A point estimate should never conceal that sensitivity.

A genuinely binding threshold must specify the institution's obligation and available resources. Examples include required benefit cash against liquid assets and expected receipts, or assessed care hours against staffed hours. The report does not combine unrelated indicators into a weighted collapse index.

The alternative baseline changes the scale

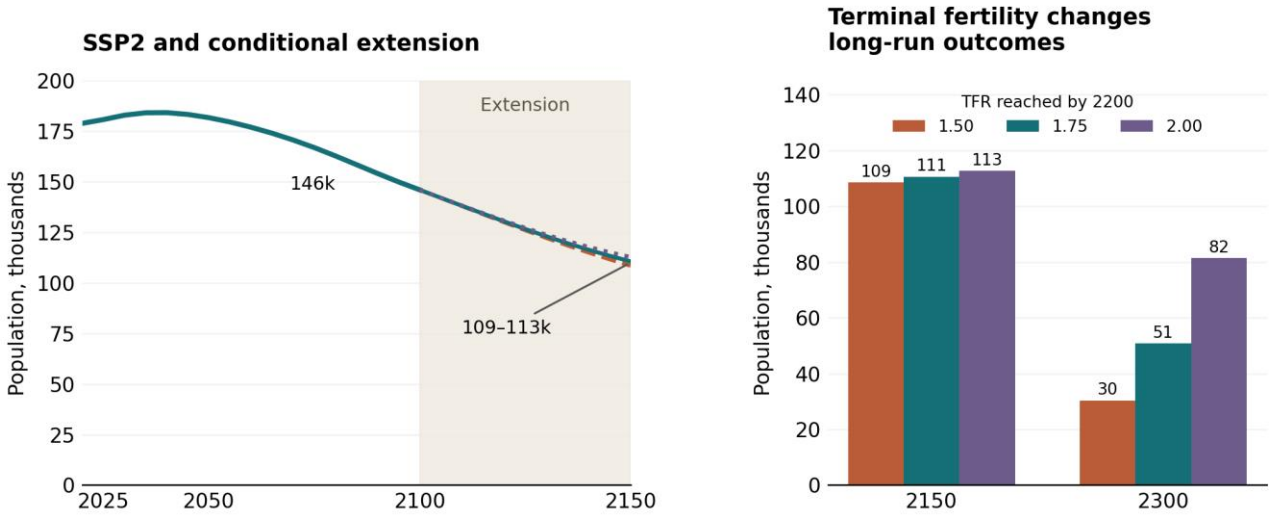


Figure 8. Independently reproduced WIC 2023 V 15 SSP 2 and SSP2300_V02 fertility sensitivities. Stocks are 1 January, with newborn flow rows excluded. The shaded region is a conditional extension beyond 2100. The bars reveal sensitivity to imposed terminal fertility; they are not probability intervals. [D3–D4]

The alternative SSP 2 population is about 181,700 in 2050 and 146,000 in 2100, materially above the UN benchmark. It also has more older residents: about 40,100 aged 65+ in 2050 and 54,800 in 2100. A larger total does not necessarily remove ageing pressure. The series keeps its own 2020 baseline and assumptions; it is not rescaled to the UN or census total.

With the same census rate profiles, SSP 2 employment support falls from 50.1 per 100 residents in 2025 to 46.7 in 2050. Preserving its own starting ratio requires about 6,190 additional workers or 7.29% more output per worker; its care proxy per worker rises 94.5%. Thus the alternative strengthens the same institutional conclusion. Its January 2025 baseline differs from the UN's July 2026 baseline, so this is a direction check rather than an isolated parameter experiment.

Beyond 2100, the published extension imposes zero net migration. Fertility converges by 2200 toward 1.75, with alternative terminal values 1.50 and 2.00. Life expectancy gains continue toward a ceiling of 105 years, and education survival differences converge. These terminal rules are conditional choices, especially restrictive for an open island. They are not extended assumptions about future pension laws or medical technology.

The terminal-fertility variants give roughly 108,500–112,800 residents in 2150, but 30,400–81,500 by 2300. Much of the 2150 population is already alive in 2100, and fertility convergence is gradual. The expanding long-run spread illustrates accumulated assumption sensitivity; neither endpoint supplies a national viability threshold.

Priority actions through 2030

Make pension adjustment reviewable

NIC and the ministry responsible for social security should release the full latest actuarial review, recent audited accounts and a current-law update that includes recent benefit changes. Publish contributor months, insurable payroll, beneficiaries and benefit amounts by age and sex, together with cash-flow and liquidity scenarios. This is a low-regret prerequisite to selecting a contribution path. Success is a shorter publication lag and a reform comparison that reports both solvency and benefit adequacy.

NIC and Inland Revenue should simplify employer reporting and reduce contribution gaps. Coverage reform should protect irregular and low-income earners. Additional contributors improve current receipts but acquire future rights; higher wages can increase both contributions and pension obligations. Rate increases reduce take-home pay and increase employer costs, while later eligibility is harder for unhealthy people and manual workers. Phase any enacted adjustment with disability and hardship safeguards. No costed or optimal reform rate can be justified from the retrieved accounts alone.

Expand employment alongside childcare and care support

The labour ministry, employers, education providers and social services should connect employment services, childcare and transport to the groups with the largest employment gaps. Measure sustained jobs and insured months, rather than training places alone. The model's employment uplift is a testable target, not an estimated effect of one programme. Start with pilots that report costs per sustained additional worker and distribution by sex, age, district and disability.

More paid work can remove time previously used for childcare or elder care. A programme that counts additional workers but ignores replacement care overstates the net gain. Formal carers need paid training, safe staffing and predictable hours. Improving working conditions can retain nurses and other skilled workers more quickly than training an entirely new cohort, while training capacity takes several years to expand.

Turn migration policy into a retention programme

The departments responsible for labour, immigration and diaspora affairs should publish occupation-specific vacancies and retention indicators, recognize suitable returning residents' qualifications, and make recruitment and work-permit processing predictable. Target the loss of essential skills as well as net headcount. Fair employment protections for migrants help prevent a low-wage recruitment strategy from worsening conditions for existing residents.

The modelled migration improvement is net of departures. It does not mean that the same number of visas produces the required gain: entrants may leave, residents may emigrate and returning residents may be older. Housing, school places and care access are implementation requirements. Annual age–sex inflows and outflows, retention after two and five years, and critical vacancy rates are the essential indicators.

Build care capacity and family security

A care workforce plan before the larger older cohorts arrive

The Ministry of Health, Sir Arthur Lewis Community College, care providers and professional councils should link training places to funded posts, supervisory capacity and retention. Commission a care-needs and time-use survey, establish safe home-care standards and offer respite support. Publish filled full-time-equivalent posts and actual service hours by district. Counts on a professional register are not the same as people currently delivering care.

Healthy ageing can reduce or postpone some disability, but longer lives do not automatically mean fewer years requiring assistance. Prioritize accessible primary care, prevention and management of chronic disease, rehabilitation and home adaptations. The model's lower disability-prevalence sensitivity is an outcome to monitor, not a promise that spending a specified sum will produce it. The distributional test is whether low-income and rural households receive support, rather than whether national expenditure rises.

Support family choices with durable services

Affordable childcare, stable housing, predictable work schedules and reproductive healthcare can reduce the costs of raising children. Their value includes child development and parental wellbeing even if fertility does not rise. Respect reproductive choice. A fertility scenario represents an assumed outcome, not proof that payments or campaigns can deliver a target birth rate.

The budget must distinguish recurrent service commitments from one-off capital costs. New births increase service needs well before they contribute to employment or pensions. Family support is therefore a long-term social investment, while retention and employment can affect the resource base sooner. Evaluate affordability, childcare access and parents' ability to work alongside fertility itself.

Use technology where tasks can actually change

Finance, digital-government teams and employers should test technology against measurable output: time to process a claim, appointments completed, or records retrieved reliably. AI may assist administration, scheduling, documentation and some diagnostic workflows; adoption needs reliable systems, training, privacy controls and professional oversight. A national productivity sensitivity does not imply an equal increase in nursing time or usable blood donations.

Procure systems with an exit plan, interoperable data and continuing maintenance funding. Report net staff time saved after checking and correction, rather than gross model-generated output. Protect service access for people who cannot use digital channels. Productivity improves public financing only through identifiable channels such as taxable earnings, insurable payroll, lower unit costs or additional service output.

Sequence reforms and monitor delivery

Period	Priority and accountable bodies	Observable decision test
Next 12 months	CSO, NIC, Finance and Health reconcile baselines; publish pension evidence and staffing/care inventories.	Current-law cash flows, age–sex employment and migration, filled posts and care-hours baseline available.
2027–2030	Labour and social services pilot employment and childcare packages; Health and SALCC expand funded training and retention; immigration teams improve skilled recruitment.	Sustained insured jobs, programme unit costs, vacancy duration, retention and district service access improve.
2030–2040	Scale successful care and employment programmes; phase legally adopted pension adjustments; review school estate and regional specialist services.	Care output keeps pace with assessed need; adequacy and liquidity pass published tests; travel burdens do not rise unchecked.
After 2040	Reassess pension parameters and facilities against observed cohorts, migration and household geography.	Five-year reviews replace fixed century-long policy assumptions.

The most useful policies across scenarios are timely pension disclosure, better employment matching, support for unpaid carers, retention of essential professionals, accessible housing and shared specialist services. The value of large fertility incentives, population-based infrastructure expansion or aggressive immigration targets depends more heavily on uncertain behavioural responses and local capacity.

The model demonstrates the arithmetic cost of delay, but does not calculate a benefit–cost ratio. Costs cannot be credibly stated without programme design, wage scales, procurement and facility plans. The first budget should fund the data and pilots needed to cost the next stage, with a published cap and explicit expansion criteria.

A smaller population remains compatible with a functioning and prosperous nation if institutions adapt. The urgent decisions concern who works, who contributes, who gives care, and how obligations are financed. Waiting for a single population number to declare a national emergency would miss pressures that can emerge much earlier within particular services.

Uncertainty and the evidence needed next

Measurement uncertainty. The census uses substantial undercount adjustments; the annual estimates and UN historical reconstruction are not reconciled. Detailed census tables contain minor rounding differences and some summary inconsistencies. Employment and disability rates are measured for household populations but applied to all-resident projections, which can overstate capacity or misstate needs in institutional ages.

Scenario uncertainty. Fertility and migration paths have no assigned probabilities. The latest local fertility is below the UN near-term assumption. Gross migration, skilled-worker selection, migrant employment and return migration are not identified. The model's fertility scaling and calibrated transitions are sensitivities, not a fully re-estimated demographic system.

Institutional uncertainty. Employment is a headcount, not full-time-equivalent hours, productivity or NIC coverage. Disability is not clinical care demand. Pension accounts retrieved end in 2021. No current actuarial depletion date, national care-staff requirement or blood-supply crossing can be independently calculated from these inputs.

Missing variable	Likely custodian	What it would resolve
Rebased age–sex stocks; matched birth/death series; migration inflows and outflows	CSO, Civil Status Registry, Immigration	Population baseline, natural change, retention and age allocation.
Age–sex employment hours, earnings and survey weights	CSO and labour ministry	Current employment/FTE profile and sensitivity to census rates.
Contributor months, insurable earnings, pensioner files, recent audited accounts and full valuation	NIC and social-security ministry	Current-law cash flows, adequacy, reserve liquidity and reform costs.
Care severity, unmet hours, unpaid time, filled FTE posts, attrition and placement	Health and social services, professional councils, SALCC	Real service-capacity gap and training/retention requirements.
Blood collections, deferrals, usable yield, requests and stockouts	National Blood Bank, MHMC, St Jude Hospital	Operational minimum stock and supply–demand gap.
School-level costs, enrolment, travel and staffing; dwelling use and vacancies	Education, CSO and planning authorities	Local fixed-cost and access decisions.

An annual public monitoring report should show the observed series alongside projections, retain prior vintages and explain revisions. Re-estimate the demographic and institutional scenarios after each major census rebasing, actuarial update or material policy change. Policy should respond to measured obligations and service gaps, with citizens able to see which assumptions changed.

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Technical appendix A Data and transformations

The central numerical reproduction below requires Python with numpy and pandas, internet access and several hundred megabytes of temporary disk space. It downloads full worldwide UN CSVs, filters Saint Lucia (LocID 662) and the Medium variant, and embeds the census employment/disability inputs. It writes milestone, threshold, sensitivity and timing outputs. No separate spreadsheet is needed to understand the calculations. Charts are visualizations of these outputs.

WPP stock files use thousands of people, converted to persons by multiplying by 1,000. ASFR is annual births per 1,000 women at each age, divided by 1,000. Life-table survival is unitless. The model uses 1 July stocks, ages 0–99 and open 100+. Annual demographic indicators are calendar-year flows; they are not summed into population stocks. The separately retrieved 1 January file provides a diagnostic only.

The five essential filenames, downloaded from the base URL in the code, are:

WPP2024_PopulationBySingleAgeSex_Medium_2024-2100.csv.gz

WPP2024_Demographic_Indicators_Medium.csv.gz

WPP2024_Fertility_by_Age1.csv.gz

WPP2024_Life_Table_Complete_Medium_Male_2024-2100.csv.gz

WPP2024_Life_Table_Complete_Medium_Female_2024-2100.csv.gz

For stock outputs, male and female single-age cells are the internally consistent modelling unit. Their independently rounded sum differs slightly from the aggregate indicator:2026 model 180,510 versus headline 180,488;2050 model 172,118 versus headline 172,080;2100 model 108,262 versus headline 108,207. This is a rounding/convention distinction, not a source correction. Narrative model results are rounded to hundreds.

Census employment uses detailed Table 10.10, not the inconsistent 65+ employment subtotal in summary TableD.9. Male/female employment cells reproduce 82,608. Rates retain people with unstated labour status in the denominator. Under 15 employment is zero;90+ rates continue through the oldest ages. Disability uses Table 11.1 some-disability counts divided by age-group population, with the 90+ rate extended and under 5 excluded. The code preserves adjusted-table rounding rather than forcing totals.

The WIC alternative uses SSP2300_V02 files PROJresult_AGE_SSP22300_V02.csv, PROJresult_AGE_SSP2TFR150_V02.csv and PROJresult_AGE_SSP2TFR200_V02.csv, from record 23016234. Filter region=reg662 and region_level=country; exclude agest=−5. That row represents period births/deaths, not a stock. Sum population over both sexes and six education groups, multiply 1,000. Stocks are 1 January and the open oldest band is 120+. [D4]

Technical appendix B Equations and model limits

Let O(s,a,t) be the official age–sex stock and P(s,a,t) a scenario stock. For positive benchmark source cells, the cohort rule is:

```
P(s,a+1,t+1) = P(s,a,t) * O(s,a+1,t+1) / O(s,a,t)
P(s,100+,t+1) = (P(s,99,t)+P(s,100+,t)) *
    O(s,100+,t+1) / (O(s,99,t)+O(s,100+,t))
```

The implementation decomposes this into survival S and a benchmark residual R=O_next−S×O_source, then applies S×P_source+R×P_source/O_source. Survival cancels algebraically in positive-source cells, yielding the ratio above. R is not observed migration: it includes timing and rounding as well as net migration. This is a calibrated cohort sensitivity; mortality and migration cannot be independently identified from it. For rare zero rounded source cells, residual scaling uses total scenario/benchmark population.

For newborns, B*=Σa ASFR(a,t)×P(female,a,t), ages 15–49. The next newborn stock equals the official sex-specific newborn stock multiplied by B*/B*official and by scenarioTFR/officialTFR. This retains the official newborn sex split and absorbs within-year birth timing, infant survival and infant migration. ASFR sums differ from published totalTFR by less than 0.25% at checked dates; the fertility targets are schedule-scaling approximations, not independently verified full-age birth totals.

Additional net migration equals δ×Ptotal(t)×ramp, with δ=±0.002 and ramp=min(max((t+1−start)/5,0),1). Each of 40 sex–single-age cells 20–39 receives 1/40. Fertility blends each year's UN value toward 1.15 over 10 years or 1.80 over 15 years. Everyone subsequently ages; female arrivals contribute to future newborn exposure. The benchmark cohort pattern remains conditional and may include population-adjustment error.

```
E_t = sum(employment_rate[sex,age] * P[sex,age,t])
D_t = sum(disability_rate[age] * P[sex,age,t])
r0 = E_2026 / P_2026
extra_E = max(0, r0 * P_t - E_t)
output_gain = max(0, r0 * P_t / E_t - 1)
annual_gain = (1 + output_gain)**(1/(t-2026)) - 1
aggregate_gain = max(0, E_2026 / E_t - 1)
care_capacity_index = 100 * D_t / D_2026
care_load_index = 100 * (D_t/E_t) / (D_2026/E_2026)
```

Output offsets assume constant hours and resource capture per employed person. They can represent real earnings only if productivity gains reach workers; tax and NIC receipts then require the appropriate tax base, contribution ceiling and compliance. They are not forecasts of Treasury balances. Central-government transfers to NIC must be counted once if consolidating the public sector; interest received by NIC from government is also a government payment, not new national income.

Technical appendix C Validation and alternative baseline

Check	Executed result	Interpretation
UN benchmark recovery	Maximum age–sex stock error 0	Calibration identity; not predictive validation.
Cohort values and ages	Finite, nonnegative;0–100+ retained	No negative populations. Open oldest cohort pooled.
Age groups and units	Disjoint groups sum to model total	Thousands converted to people; sex-cell rounding retained.
Survival conventions	S 1=L 1/L 0;S 100=T 100/T 99	Destination-age indexing checked; life tables diagnose transitions.
Stock/flow check	January residual versus age migration differed about 1–2 people per cell at checked years	Approximate timing consistency only; no independent custom births/deaths accounting.
Census employment	Male+female employed 82,608	Matches published overall total. Minor weighted-cell rounding remains.
SSP extraction	Unique cohort keys; nonnegative; variants identical through 2100	Newborn-flow rows excluded; post 2100 net migration verified zero.
Pension accounting	Both audited annual surpluses reconcile exactly	Accounting totals reproduced; future solvency not validated.

The independently reproduced SSP 2 institutional test uses the same census employment and disability rates, aggregated across education. It preserves its own January 2025 reference rather than being rescaled to July 2026. This tests whether conclusions survive a credible alternative baseline; it does not isolate one assumption.

Alternative SSP 2 year	Employed per 100	Change from 2025	Care proxy per worker change
2025	50.11	—	—
2030	49.94	−0.35%	+11.82%
2040	48.49	−3.23%	+47.29%
2050	46.70	−6.80%	+94.46%
2075	41.23	−17.72%	+249.01%
2100	38.63	−22.90%	+367.45%

SSP 2 needs about 6,190 additional employed people in 2050 to preserve its 2025 support ratio, or 7.29% more output per worker. The UN equivalent is 3,863 or 4.66% against 2026. Both give falling employment support and substantially rising care pressure. The genuine historical check in this study is the Moonie household comparison; reproducing current official projections is not historical validation.

Technical appendix D Scenario results

All counts below are thousands of people, rounded to one decimal. E is employment at fixed 2022 age–sex rates; D is the age-weighted disability proxy. Rounding can prevent visible subtotals from adding exactly. The 2026 row is common to all scenarios.

Benchmark

Year	Population	E	Age 65+	Age 80+	D
2026	180.5	91.0	18.7	3.0	5.6
2030	181.4	91.5	22.0	3.3	6.0
2040	179.3	88.9	29.5	5.1	7.4
2050	172.1	82.9	35.1	8.0	8.8
2075	141.2	60.4	44.6	14.3	10.8
2100	108.3	45.0	36.0	13.5	9.4

Low fertility and outflow

Year	Population	E	Age 65+	Age 80+	D
2026	180.5	91.0	18.7	3.0	5.6
2030	180.3	91.0	22.0	3.3	6.0
2040	171.9	85.7	29.5	5.1	7.3
2050	158.0	76.9	35.1	8.0	8.6
2075	110.9	46.3	41.5	14.1	10.0
2100	66.8	25.8	29.0	11.5	7.4

Retention and return

Year	Population	E	Age 65+	Age 80+	D
2026	180.5	91.0	18.7	3.0	5.6
2030	182.1	92.0	22.0	3.3	6.0
2040	184.3	92.1	29.5	5.1	7.5
2050	181.9	88.9	35.1	8.0	8.9
2075	162.5	71.7	47.7	14.5	11.6
2100	137.5	58.9	42.8	15.8	11.2

Fertility recovery

Year	Population	E	Age 65+	Age 80+	D
2026	180.5	91.0	18.7	3.0	5.6
2030	181.8	91.5	22.0	3.3	6.0
2040	182.9	88.9	29.5	5.1	7.4
2050	179.8	83.3	35.1	8.0	8.8
2075	160.4	67.5	44.6	14.3	11.0
2100	140.9	60.0	37.4	13.5	10.0

Combined adaptation

Year	Population	E	Age 65+	Age 80+	D
2026	180.5	91.0	18.7	3.0	5.6
2030	182.5	92.0	22.0	3.3	6.0
2040	188.1	92.2	29.5	5.1	7.5
2050	190.2	89.4	35.1	8.0	9.0
2075	184.5	79.9	47.8	14.5	11.8
2100	177.3	77.1	44.7	15.9	12.0

Technical appendix E Thresholds and offsets

Scenario	Support −5% year	Care +25% year	Care years to 2050	Old-age ratio 30/100 year
Benchmark	2052	2037	14	2050
Low fertility and outflow	2054	2036	15	2047
Retention and return	2056	2038	13	2053
Fertility recovery	2044	2037	14	2050
Combined adaptation	2046	2038	13	2054

Exact years are calculation outputs for audit. For policy interpretation, use the windows reported in the narrative. All five scenarios cross the listed demographic warning thresholds within 2100; none establishes national failure. The benchmark support warning is not crossed by 2050. A different chosen warning level changes the date.

Year	Extra employed benchmark	Real output gain	Annual gain 2026 to year	Care capacity 2026=100
2030	0	0.00%	0.000%	108.6
2040	1,490	1.68%	0.119%	133.4
2050	3,863	4.66%	0.190%	157.5
2075	10,734	17.77%	0.334%	194.6
2100	9,551	21.22%	0.260%	168.6

The accounting identity for NIC is Δreserves=contributions+investment/other income−benefits−administration−other costs, subject to valuation and consolidation conventions. Current liquidity depends on cash and realizable assets, not all recognized income. Benefit adequacy requires a separate current cost-of-living or poverty benchmark and beneficiary information.

```
# FY2020/21 historical accounting, EC dollars
C=117621805; B=119698523; A=21611674
other_income=215370461; emergency=20429566
finance=29250; tax=47132
assert C+other_income-B-A-emergency-finance-tax == 171176121
print(C/(B+A), (B+A)-C)   # 0.832366, 23688392
base=C/0.10
print(0.01*base, (B+A)/base) # 11762180.5, 0.120139
# Additional independent sensitivities in the narrative
print(157.5329615*.8,172.9157846*.8) # all-age prevalence -20%
print(172.9157846/1.05833151246)      # employment +5pp
print(100*(1.05833151246*1.005**24-1)) # combined resource gain
```

Technical appendix F Executable core reproduction

Save the following as reproduce.py, install numpy and pandas in a Python environment, and run python reproduce.py. Source downloads are cached beside the script. The file reproduces the central numerical outputs; plot styling is not needed to reproduce findings. The code continues over the following pages.

```
"""Saint Lucia WPP-calibrated annual cohort sensitivity, 2026–2100.
All stocks persons, 1 July; official CSVs originally thousand persons.
Execute: python reproduce.py
"""
from pathlib import Path
import numpy as np,pandas as pd,json,hashlib
P=Path(__file__).parent
START=2026; END=2100; YEARS=range(START,END+1)
# Requires Python 3.11+, numpy and pandas; first run downloads UN inputs.
import urllib.request, urllib.parse
BASE = 'https://population.un.org/wpp/assets/Excel Files/1_Indicator (Standard)/CSV_FILES/'
FILES = ['Demographic_Indicators_Medium',
 'PopulationBySingleAgeSex_Medium_2024-2100',
 'Life_Table_Complete_Medium_Male_2024-2100',
 'Life_Table_Complete_Medium_Female_2024-2100', 'Fertility_by_Age1']
for f in FILES:
 dest=P/('LCA_'+f+('_Medium' if f=='Fertility_by_Age1' else '')+'.csv')
 if dest.exists(): continue
 archive=P/('WPP2024_'+f+'.csv.gz')
 if not archive.exists():
  urllib.request.urlretrieve(urllib.parse.quote(BASE+archive.name,safe=':/'),archive)
 parts=[]
 for chunk in pd.read_csv(archive,chunksize=100000,low_memory=False):
  parts.append(chunk[(chunk.LocID==662)&(chunk.Variant=='Medium')])
 pd.concat(parts).to_csv(dest,index=False)
raw=pd.read_csv(P/'LCA_PopulationBySingleAgeSex_Medium_2024-2100.csv')
O={y:raw[raw.Time==y].sort_values('AgeGrpStart')[['PopMale', \
  'PopFemale']].to_numpy().T*1000 for y in range(2024,2101)}
ind=pd.read_csv(P/'LCA_Demographic_Indicators_Medium.csv').set_index('Time')
fert=pd.read_csv(P/'LCA_Fertility_by_Age1_Medium.csv');fert=fert[fert.Variant=='Medium']
F={y:np.array([0.0]*15+fert[fert.Time==y].sort_values('AgeGrpStart').ASFR.tolist()+[0.0]*51)/ \
  1000 for y in YEARS}
S={y:np.stack([pd.read_csv(P/f'LCA_Life_Table_Complete_Medium_{sex}_2024-2100.csv').query( \
  'Time==@y').sort_values('AgeGrpStart').Sx.to_numpy() for sex in ['Male', \
  'Female']]) for y in YEARS}
# Census employment-to-population rates by age and sex (Table10.10, pp125–126).
from io import StringIO
CENSUS = ("age_lower,population_both,employed_both,"
 "population_male,employed_male,population_female,employed_female\n") + """
15,11463,1909,5951,1088,5512,821
20,11789,7280,5938,3758,5851,3522
25,12819,9225,6325,4681,6493,4544
30,12847,9699,6165,4813,6683,4886
35,13335,10236,6291,5016,7043,5220
40,12292,9637,6220,5003,6072,4634
45,11994,9303,5918,4859,6076,4444
50,11953,8843,5885,4702,6068,4141
55,11170,7459,5659,4152,5511,3307
60,9268,4826,4561,2751,4707,2075
65,7054,2339,3534,1475,3520,864
70,4999,1103,2331,684,2668,419
75,3753,513,1758,325,1995,188
```

Executable reproduction continued

```
80,2398,176,987,104,1411,72
85,1519,54,608,29,912,25
90,858,7,275,5,583,1
"""
census=pd.read_csv(StringIO(CENSUS)).set_index('age_lower')
ER=np.zeros((2,101))
for a in range(15,101):
 r=census.loc[min(a//5*5,90)]
 ER[:,a]=[r.employed_male/r.population_male,r.employed_female/r.population_female]
# Some-disability prevalence, age5+ (Table11.1, p127); no under5 coverage.
denom=np.array([11096,11352,11463,11789,12819,12847,13335,12292,11994,11953,11170,9268,7054, \
  4999,3753,2398,1519,858])
num=np.array([89,135,102,104,144,135,186,190,208,346,401,524,594,610,703,657,573,457]); \
  DR=np.zeros(101)
for a in range(5,101): DR[a]=(num/denom)[min(a//5-1,17)]
def ramp(y,start,n): return np.clip((y-start)/n,0,1)
def forward(x,y,target_tfr=None,delta_mig=0.,start=2026):
 # Official age-specific survival plus proportional reconciliation residual.
 src=x[:,:-1].copy();src[:,-1]+=x[:,-1]
 osrc=O[y][:,:-1].copy();osrc[:,-1]+=O[y][:,-1]
 sv=S[y][:,1:];res=O[y+1][:,1:]-osrc*sv
 scale=np.divide(src,osrc,out=np.full_like(src,x.sum()/O[y].sum()),where=osrc>0)
 nxt=np.zeros_like(x);nxt[:,1:]=src*sv+res*scale
 # Calibrated newborn conversion absorbs birth timing, infant survival and
 # benchmark infant migration; no independent estimate of these residuals.
 b=np.dot(x[1],F[y]);b0=np.dot(O[y][1],F[y])
 mult=1 if target_tfr is None else target_tfr/ind.loc[y,'TFR']
 nxt[:,0]=O[y+1][:,0]*(b/b0)*mult
 # Added/retained net residents: equal M/F, uniformly20–39 at end-year.
 increment=delta_mig*x.sum()*ramp(y+1,start,5)
 nxt[:,20:40]+=increment/40
 if not np.isfinite(nxt).all(): raise ValueError('nonfinite cohort')
 if nxt.min()<0: raise ValueError('negative cohort')
 return nxt,increment
SC={'Benchmark':(None,0.),'Low fertility and outflow':(1.15,-.002), \
  'Retention and return':(None,.002),'Fertility recovery':(1.8,0.), \
  'Combined adaptation':(1.8,.002)}
def run(name,start=2026):
 target,mig=SC[name];pop={START:O[START].copy()};flows={START:0.}
 for y in range(START,END):
  tfr=None if target is None else ind.loc[y,'TFR']+(target-ind.loc[y,'TFR'])*ramp(y+1,start, \
    10 if target==1.15 else 15)
  pop[y+1],flows[y+1]=forward(pop[y],y,tfr,mig,start)
 return pop,flows
POP={}; rows=[]
for name in SC:
 POP[name],flows=run(name)
 for y,x in POP[name].items():
  total=x.sum();e=(x*ER).sum();old=x[:,65:].sum();w=x[:,15:65].sum();child=x[:,:15].sum(); \
    d=(x*DR).sum()
  rows.append(dict(scenario=name,year=y,population=total,employed=e,age0_14=child,age15_64=w, \
    age65plus=old,age80plus=x[:,80:].sum(),disability_proxy=d,employed_per100=100*e/total, \
```

Executable reproduction continued

```
    old_dependency=100*old/w,total_dependency=100*(old+child)/w, \
    incremental_net_migration=flows[y]))
r=pd.DataFrame(rows);base=r[(r.scenario=='Benchmark')&(r.year==START)].iloc[0]; \
  elapsed=r.year-START
r['extra_employed_for_support']=np.maximum(0, \
  r.population*base.employed/base.population-r.employed)
r['earnings_gain_pct']=100*r.extra_employed_for_support/r.employed
r['annual_earnings_growth_pct']=100*((1+r.extra_employed_for_support/r.employed)**(1/elapsed. \
  replace(0,np.nan))-1)
r['aggregate_earnings_gain_pct']=100*np.maximum(0,base.employed/r.employed-1)
r['aggregate_annual_growth_pct']=100*((1+r.aggregate_earnings_gain_pct/100)**(1/elapsed. \
  replace(0,np.nan))-1)
r['care_staff_per100_today']=100*r.disability_proxy/base.disability_proxy
r['care_load_per_worker_index']=100*(r.disability_proxy/r.employed)/(base.disability_proxy/ \
  base.employed)
r.to_csv(P/'results_annual.csv',index=False)
r[r.year.isin([2026,2030,2040,2050,2075,2100])].to_csv(P/'results_milestones.csv',index=False)
# One-at-a-time overlays and early versus delayed starts, through2050.
rr=[]
for timing,start in [('Early',2026),('Delayed',2036)]:
 pp,_=run('Combined adaptation',start)
 for y,x in pp.items():
  er=ER.copy();er[:,25:65]+=0.05*ramp(y,start,10)
  e=(x*er).sum();old_er=ER.copy();old_er[:,65:75]+=0.05*ramp(y,start,10)
  rr.append(dict(timing=timing,year=y,population=x.sum(),employed=e, \
    employed_per100=100*e/x.sum(),older_work_effect=(x*(old_er-ER)).sum()))
tim=pd.DataFrame(rr);tim.to_csv(P/'timing.csv',index=False)
# Sensitivities at2050, resources measured employed-equivalent real output/person.
y=2050
bench=r[(r.scenario=='Benchmark')&(r.year==y)].iloc[0]
x=POP['Benchmark'][y]
vals=[]
for name in ['Low fertility and outflow','Retention and return','Fertility recovery', \
  'Combined adaptation']:
 z=r[(r.scenario==name)&(r.year==y)].iloc[0];vals.append([name, \
   100*((z.employed/z.population)/(bench.employed/bench.population)-1)])
for name,ages in [('Employment +5pp at25–64',slice(25,65)),('Employment +5pp at65–74', \
  slice(65,75))]:
 er=ER.copy();er[:,ages]+=.05;vals.append([name,100*((x*er).sum()/bench.employed-1)])
vals.extend([['Real output per worker +0.5%/yr',100*(1.005**24-1)], \
  ['Real output per worker +1%/yr',100*(1.01**24-1)]])
pd.DataFrame(vals,columns=['sensitivity', \
  'resource_per_resident_change_pct']).to_csv(P/'sensitivities.csv',index=False)
# Thresholds pre-defined illustrative monitoring triggers, not viability limits.
thresholds=[]
for name in SC:
 z=r[r.scenario==name]
 for label,mask in [('Support5%below2026',z.employed_per100<.95*base.employed_per100), \
   ('Oldage_dependency30per100',z.old_dependency>=30),('Careload25%above2026', \
   z.care_load_per_worker_index>=125),('Careload10%above2026', \
   z.care_load_per_worker_index>=110),('Careload50%above2026',z.care_load_per_worker_index>=150)]:
  hit=z[mask];thresholds.append(dict(scenario=name,threshold=label, \
```

Executable reproduction continued

```
    first_year=None if hit.empty else int(hit.year.iloc[0]),years_crossed=int(mask.sum()), \
    years_crossed_to2050=int((mask & (z.year<=2050)).sum())))
pd.DataFrame(thresholds).to_csv(P/'thresholds.csv',index=False)
# Climate illustrative5%,3%,1% employment shock2030–32, no migration shock.
b=r[r.scenario=='Benchmark'].set_index('year');lost=sum(b.loc[y,'employed']*q for y, \
  q in [(2030,.05),(2031,.03),(2032,.01)])
# Validation official published both-sex totals round independently of sex sums.
err=max(np.max(abs(POP['Benchmark'][y]-O[y])) for y in YEARS)
checks={'benchmark_max_cohort_error_people':float(err), \
  'minimum_cohort_people':float(min(x.min() for pp in POP.values() for x in pp.values())), \
  'sexsum_max_difference_vs_published_both_people':float(max(abs(O[y].sum()-1000*raw[raw.Time \
  ==y].PopTotal.sum()) for y in YEARS)),'climate_lost_worker_years':float(lost), \
  'early_minus_delayed_worker_years_2027_2050':float(tim.query( \
  'timing=="Early" and year<=2050 and year>2026').employed.sum()-tim.query( \
  'timing=="Delayed" and year<=2050 and year>2026').employed.sum()), \
  'census_employed_sexrows':int(census.employed_male.sum()+census.employed_female.sum())}
checks['healthy_ageing20pct_lower_old_disability_2050'] = float((POP['Benchmark'][2050]*DR*np \
  .where(np.arange(101)>=65,.8,1)).sum())
checks['older_disability_share_2050'] = float((POP['Benchmark'][2050][:, \
  65:]*DR[65:]).sum()/(POP['Benchmark'][2050]*DR).sum())
json.dump(checks,open(P/'validation.json','w'),indent=2)
np.savez_compressed(P/'populations.npz',**{f'{n}_{y}':x for n,pp in POP.items() for y, \
  x in pp.items()})
print(r[r.year.isin([2026,2030,2040,2050,2075,2100])].round(2).to_string(index=False)); \
  print(checks)
```

Technical appendix G Other reproduced calculations

For the SSP comparison, download the three exact CSV filenames in AppendixA from the linked Zenodo record. This code excludes newborn flows and sums education groups. Apply the same employment and disability arrays embedded in the core code to sex–age totals for the institutional check. Ages above 90 use the 90+ rates; dates remain 1 January.

```
import pandas as pd
files=["PROJresult_AGE_SSP22300_V02.csv",
       "PROJresult_AGE_SSP2TFR150_V02.csv",
       "PROJresult_AGE_SSP2TFR200_V02.csv"]
for f in files:
    selected=[]
    for c in pd.read_csv(f,chunksize=100000):
        selected.append(c[(c.region=="reg662") &
            (c.region_level=="country") & (c.agest>=0)])
    d=pd.concat(selected)
    assert not d.duplicated(["Time","sex","edu","agest"]).any()
    assert (d["pop"]>=0).all()
    print(f, d.groupby("Time")["pop"].sum()*1000)
    # Aggregate education before applying census rate profiles.
    age=d.groupby(["Time","sex","agest"])["pop"].sum()*1000
    print(age)
```

The household comparison uses the exact input counts below. Linear interpolation is an analytical bridge to 2022, not an original Moonie projection year. The census is provisional and weighted, so differences are not precise estimates of forecasting skill.

```
households_2010,households_2022=58891,65951
pop_2010,pop_2022=165595,171834
print(100*(households_2022/households_2010-1))
print(100*(pop_2022/pop_2010-1))
print(pop_2010/households_2010,pop_2022/households_2022)
print(100*21079/65951,100*5561/20580)
for v20,v25 in [(62088,64647),(63366,67630),(63634,68143)]:
    v22=v20+2/5*(v25-v20)
    print(v22,100*(v22/65951-1))
```

The analytical boundaries are deliberate. No new pension exhaustion date is produced; no national number of care workers is invented from a disability index; no mortgage rate is derived from population size; and no “empty island” date is extrapolated. The reproducible results instead quantify the scale and timing of adjustments to specified employment and care benchmarks.