SRI LANKA'S POPULATION TRANSITION: A 150-YEAR JOURNEY THROUGH THE LENS OF THE LOGISTIC GROWTH MODEL-MODELING HISTORICAL TRENDS AND FUTURE IMPLICATIONS FOR SUSTAINABLE DEMOGRAPHIC PLANNING

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Abstract

This study analyzes Sri Lanka's demographic trajectory over 150 years using a logistic growth model to estimate population carrying capacity and examine implications for sustainable demographic planning. Three scenarios were developed: (1) a long-term historical model from 1871–2024 with a carrying capacity (K) of 32.63 million, (2) a recent-period model from 1981–2024 with a K of 23.2 million, and (3) a transitional model from 1871–2012 with a K of 25 million. These scenarios capture Sri Lanka's transition from high-growth to low-growth demographic regimes.

The models were evaluated using nonlinear regression, R^2 goodness-of-fit statistics, residual analysis, and visual inspection of fitted versus observed data. Findings show that Scenario 2 (1981–2024) aligns most closely with the 2024 census population (21.76 million) and records the highest explanatory power ($R^2 = 0.998$). The results indicate that Sri Lanka has entered a phase of demographic stabilization characterized by declining fertility, outmigration, and population ageing.

These trends require a policy shift from population expansion toward resilience and adaptation, particularly in labour force planning, elder care, migration governance, and regional development. The study highlights the value of scenario-based modelling in linking demographic evidence with long-term policy decisions and provides a replicable framework for countries undergoing similar demographic transitions.

Keywords: Demographic Transition, Logistic Growth Model, Population Carrying Capacity, Sri Lanka, Fertility Decline, Sustainable Planning

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Introduction

Population dynamics are critical indicators of a nation's socio-economic health, informing policies on infrastructure, healthcare, education, and labour planning. Sri Lanka, a South Asian country that has experienced rapid demographic transitions over the past few decades, now finds itself at the crossroads of demographic maturity and population stabilization (UNDESA, 2023). The recently released Preliminary Report of the 2024 Census of Population and Housing by the Department of Census and Statistics (DCS) estimates the total population at 21.76 million, showing a slight decline in the annual growth rate compared to the 2012 Census (Department of Census and Statistics, 2025).

While national growth appears to be plateauing, regional variations are more pronounced. Districts such as Colombo, Gampaha, and Kalutara continue to experience strong population growth, reinforcing the trend of urban concentration. Conversely, several rural and agricultural districts, including Anuradhapura, Polonnaruwa, and Monaragala, have witnessed absolute population declines, which may be attributed to internal migration and declining fertility. Notably, former conflict-affected areas, including Mullaitivu, Mannar, and Kilinochchi, show some of the highest percentage increases, reflecting resettlement and development activities.

These findings raise crucial questions about Sri Lanka's future population trajectory. Will the population stabilize or begin to decline in the coming decades? How will regional disparities affect national development and resource allocation? This paper seeks to answer such questions by applying a logistic growth model to project Sri Lanka's future population while taking into account recent demographic shifts and regional patterns identified in the 2024 Census.

By evaluating growth trends through the lens of logistic modelling, which assumes a carrying capacity and environmental limitations, this study aims to provide evidence-based insights for long-term planning in the face of demographic stagnation and sub-national inequalities.

Contemporary Approaches to Population Projections in Sri Lanka

Sri Lanka has a long history of demographic forecasting, drawing upon various methodological traditions and census baselines. These projections have been vital for policy formulation in areas ranging from health and education to labour force planning. As summarized in the sections below, several key projection studies have shaped national discourse, although their methodologies and assumptions vary considerably.

Early projections, such as *Population and Labour Force Projections for Sri Lanka, 1991–2031* by Soma de Silva (based on the 1991 Census) (De Silva, 1994) and *Population and Manpower Resources 1995–2030* by A.T.P.L. Abeykoon (based on the 1981 Census) (Abeykoon, 1995), were largely grounded in traditional demographic modelling, particularly the cohort component method. These projections, while valuable at the time, were not equipped to incorporate later demographic shocks or nonlinear trends.

The projections by W.I. de Silva, notably *Population Projections for Sri Lanka, 1991–2041* and *A Population Projection for Sri Lanka for the New Millennium 2001–2101*, continued the use of the cohort component method and extended the time horizon (de Silva, 2007). However, they lacked sensitivity to subsequent structural disruptions such as the demographic consequences of the civil war, economic crises, and the COVID-19 pandemic. Although widely cited, de Silva's co-authored 2012 projection with R. de Silva (*25 Million People and Implications*) also did not account for these critical shocks and used only 2012 Census data with static assumptions (de Silva and de Silva, 2015).

In contrast, the work of Lakshman Dissanayake represents an important methodological development in population projection studies in Sri Lanka (Dissanayake, 2014). His *Medium-Term Population Projection for Sri Lanka, 2012–2037* and the more recent *Population Projection for Sri Lanka, 2022–2047* (in progress with UNFPA) employ a hybrid methodological approach, combining the cohort component method, mathematical modelling (including logistic growth functions), and microsimulation techniques. These projections attempt to incorporate the demographic impacts of major events such as the COVID-19 pandemic, the economic crisis, and earlier disruptions including the tsunami and civil conflict. As a result, they provide a broader analytical framework for understanding future population dynamics in Sri Lanka. The medium- and long-term projections developed by Dissanayake have made an important contribution to demographic research and population policy discussions in the country.

Furthermore, Dissanayake's application of a logistic growth model to estimate Sri Lanka's population approaching the 25 million marks demonstrated the potential usefulness of the model in the context of low fertility and demographic stabilization.Logistic models are particularly valuable in such contexts because they allow for non-linear growth patterns, where population growth slows as it approaches a saturation point or carrying capacity—a pattern that appears increasingly relevant to Sri Lanka's demographic transition.

By accommodating both national and subnational variations, Dissanayake's work illustrates how hybrid modelling approaches, particularly those incorporating logistic functions, can contribute to more flexible and policy-relevant population projections. Such approaches are also useful for scenario-building and long-term planning and are increasingly applied in contemporary population forecasting.

District-Level Demographic Shifts and Implications for Logistic Population Modeling

Accurate prediction of population trends requires not only an understanding of national-level aggregates but also an appreciation of regional demographic dynamics. The Preliminary Report of the 2024 Census of Population and Housing by the Department of Census and Statistics (DCS) provides updated insights into Sri Lanka's population distribution and growth, forming a critical empirical base for applying population projection models such as the logistic growth function.

The logistic model, which incorporates the concept of a carrying capacity (K), the maximum sustainable population, relies on a realistic understanding of how population growth slows as it approaches environmental or economic limits. Identifying early signs of saturation or divergence at the subnational level can help refine national projections and highlight areas where demographic momentum is concentrated or waning.

Demographic Shifts from the 2024 Census: National Stabilization, Regional Divergence

The preliminary results of the 2024 Census report a total population of 21,763,170, up modestly from 20.36 million in 2012. However, this aggregate figure conceals important regional disparities in growth patterns:

- ***Urban-centric Growth:*** The Western Province, particularly Colombo and Gampaha, continues to show strong growth, driven by migration, economic activity, and urban concentration.
- ***Resettlement Effects:*** Post-conflict districts in the Northern Province, such as Mullaitivu, Mannar, and Kilinochchi, exhibit the highest percentage increases in population, reflecting return migration and redevelopment efforts.
- ***Rural Decline:*** Districts such as Polonnaruwa, Monaragala, and Anuradhapura experienced absolute population declines, likely due to declining fertility and youth out-migration.

The observed district-level demographic shifts revealed by the 2024 Preliminary Census underscore the necessity of integrating regional heterogeneity into national population projections using the logistic growth model. While Sri Lanka's overall population growth is modest, reflecting a national trend toward stabilization, substantial variation across districts highlights different stages of demographic transition that influence local carrying capacities and growth trajectories. Urban and post-conflict districts exhibiting strong population increases, such as Gampaha, Mullaitivu, and Mannar, may represent regions that continue to experience relatively higher growth within the logistic growth framework, whereas districts experiencing population decline or stagnation, such as Anuradhapura and Polonnaruwa, may reflect areas approaching demographic stabilization. This spatial divergence is broadly consistent with the logistic model's premise that growth decelerates as environmental and socioeconomic limits are approached. It also emphasizes the importance of considering subnational demographic patterns when refining national logistic growth estimates, ensuring that projections account for region-specific dynamics rather than relying solely on aggregate data.

Empirical Summary of Population Changes: 2012–2024

A comparative analysis of the 2012 and 2024 Census data for selected districts is presented below. This snapshot provides useful insights into both the slope and curvature of the logistic model applied in the subsequent sections.

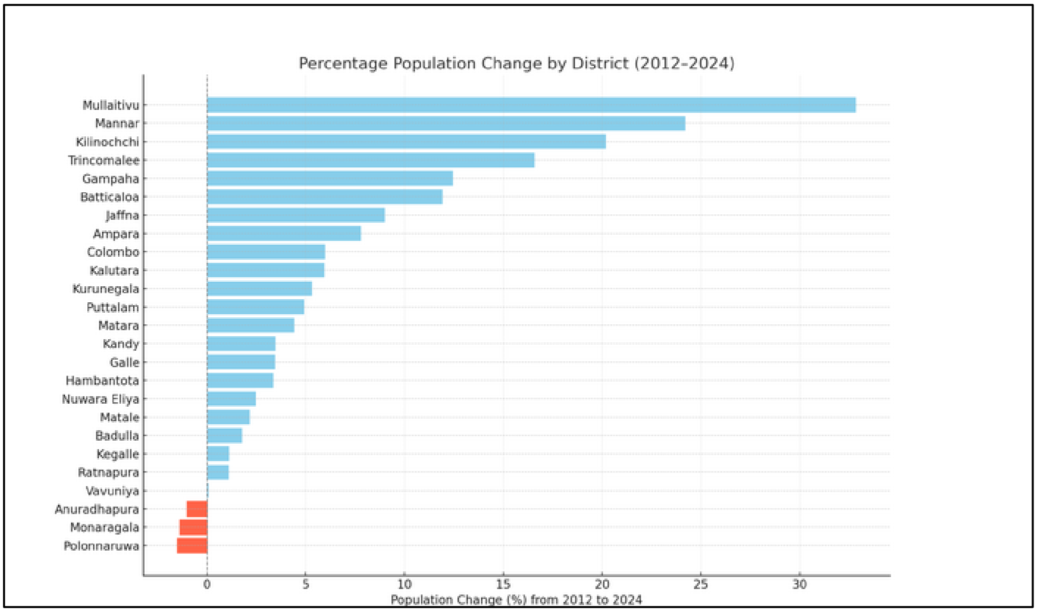
Table 1: Population Change, 2012 to 2024

District	2012 Population	2024 Population	Change	% Change
Colombo	2,309,809	2,447,932	+138,123	+5.98%
Gampaha	2,304,833	2,591,892	+287,059	+12.46%
Kalutara	1,217,260	1,289,600	+72,340	+5.94%
Kandy	1,375,382	1,423,000	+47,618	+3.46%
Matale	484,531	495,000	+10,469	+2.16%
Nuwara Eliya	711,644	729,322	+17,678	+2.48%
Galle	1,063,334	1,100,000	+36,666	+3.45%
Matara	814,048	850,000	+35,952	+4.42%
Hambantota	599,903	620,000	+20,097	+3.35%
Jaffna	583,071	635,606	+52,535	+9.01%
Kilinochchi	113,510	136,434	+22,924	+20.20%
Mannar	99,570	123,674	+24,104	+24.21%
Vavuniya	172,115	172,257	+142	+0.08%
Mullaitivu	92,238	122,542	+30,304	+32.85%
Batticaloa	526,567	589,327	+62,760	+11.92%
Ampara	649,402	700,000	+50,598	+7.79%
Trincomalee	379,541	442,465	+62,924	+16.59%
Kurunegala	1,610,299	1,696,069	+85,770	+5.32%
Puttalam	762,396	800,000	+37,604	+4.93%
Anuradhapura	860,575	851,949	–8,626	–1.00%
Polonnaruwa	406,088	400,000	–6,088	–1.50%

Badulla	815,405	830,000	+14,595	+1.79%
Monaragala	451,058	444,865	–6,193	–1.37%
Ratnapura	1,088,007	1,100,000	+11,993	+1.10%
Kegalle	840,648	850,000	+9,352	+1.11%

Source: Author's calculations based on data drawn from the Department of Census and Statistics

Figure 1: Percentage Population Change by District (2012–2024)



Source: Drawn from Table 1

Figure 1 presents a horizontal bar chart illustrating the percentage change in population across Sri Lanka's districts between 2012 and 2024. A prominent pattern emerging from the chart is the substantial population growth observed in the Northern Province, particularly in Mullaitivu, Mannar, and Kilinochchi. These districts exhibit the highest percentage increase exceeding 20% in each case—largely reflecting the impact of post-conflict resettlement. Following the end of Sri Lanka's civil war, these areas have seen the return of displaced populations, coupled with the restoration of public services and infrastructure, resulting in a demographic rebound. Similarly, Gampaha and Trincomalee show significant population gains, indicative of broader urbanization and economic restructuring. Gampaha's growth is closely tied to the urban expansion of the Colombo Metropolitan Region, acting as a residential and commercial spillover zone, while Trincomalee's increase may reflect its strategic development and evolving economic role in the Eastern Province.

In contrast, the chart also highlights demographic contraction in several interior districts. Anuradhapura, Polonnaruwa, and Monaragala recorded slight but notable population declines over the same period. This trend may be attributed to sustained out-migration of younger populations to more urbanized districts or overseas, declining fertility rates, and a gradually aging population. These regional disparities reveal a growing spatial imbalance in Sri Lanka's demographic development. While certain districts are experiencing rapid growth due to migration and economic activity, others are entering demographic stagnation or decline, potentially indicating the onset of a second demographic transition.

These patterns are particularly significant when applying the logistic growth model to project Sri Lanka's national population. The logistic model assumes that population growth slows as it approaches a carrying capacity (K), the maximum population size sustainable under prevailing environmental, economic, and social constraints. The observed sub-national disparities in demographic dynamics reinforce, rather than contradict, the relevance of the logistic model at the national level. These regional variations suggest that while some areas may still be in earlier stages of demographic transition, others may have already reached or surpassed their local carrying capacities. When aggregated, these differences balance out, supporting the idea that national-level growth is decelerating and approaching stabilization. Therefore, the logistic model remains appropriate for national projections, even as it must be complemented by regionally disaggregated analyses for more targeted policy insights.

Observed Historical Population Trend (1871–2024)

Sri Lanka's population has grown from 2.4 million in 1871 to an estimated 21.76 million in 2024 (Figure 2). This increase spans over 1.8 million people per decade on average, but the pattern of growth has not been uniform. It can be broadly divided into three major phases, each shaped by specific historical, political, public health, and demographic changes.

Phase 1: Gradual Growth (1871–1946)

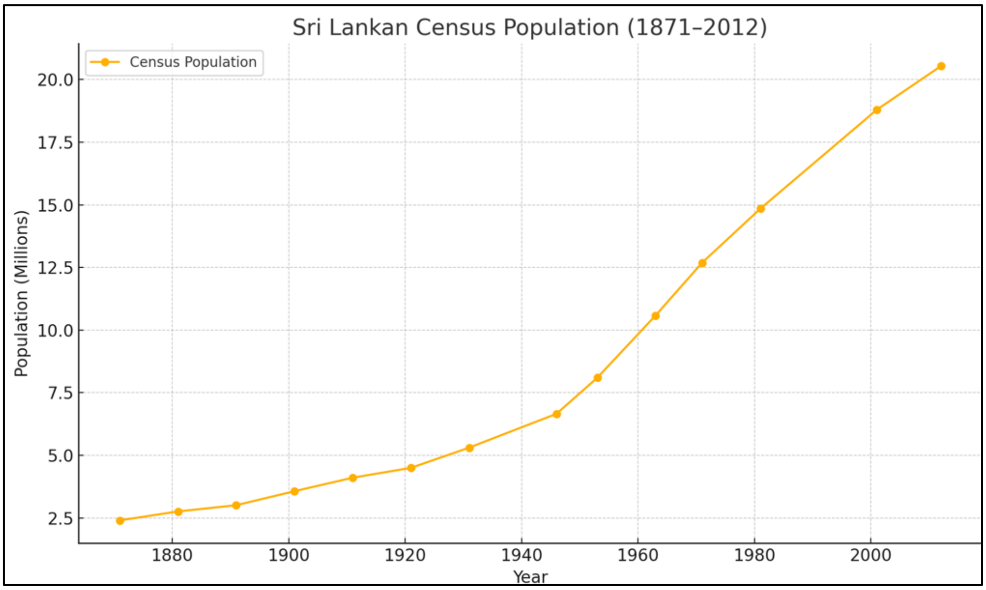
Population Change: 2.4 million → 6.7 million
Time Span: 75 years

Key Characteristics:

- **Annual Growth Rate:** Ranged from approximately 0.9% to 1.7% during this period. The growth was slow and relatively linear, particularly when compared with the post-World War II period.
- **Colonial Rule Influence:** British colonial administration focused more on plantation agriculture than on widespread population health or development initiatives. Health services were limited in scope and reach, especially in rural areas.
- **High Mortality:** Infant mortality, communicable diseases, and lack of sanitation kept natural population growth in check.
- **Small Improvements began to take place post-1930s due to:**
    - Introduction of basic public health interventions,
    - Some control of malaria and smallpox,
    - Limited development of healthcare infrastructure.

This was a pre-transition period, in which both fertility and mortality rates were high, and population growth was gradual, consistent with the early phase of the demographic transition model (Caldwell, 1986).

Figure 2: Population of Sri Lanka, from 1871 to 2024



Source: Drawn from Data Obtained from the Department of Census and Statistics for Census Years

Phase 2: Rapid Growth (1946–1981)

Population Change: 6.7 million → 14.8 million
Time Span: 35 years

Key Characteristics:

- Annual Growth Rate: Peaked at 2.8% in the 1950s.
- This phase marks the most rapid expansion in Sri Lanka's demographic history.
- Health Improvements post-independence (1948):
    - Expansion of public health services, free healthcare, and mass vaccination programs.
    - Control of malaria and reduction in infant/child mortality.
- Fertility remained high, as cultural and social norms still favored large families, and access to family planning services was limited until the late 1960s.

- The population more than doubled in just three and a half decades.

This period aligns with the exponential segment of the logistic curve, where the population grows at an increasingly rapid pace due to mortality decline preceding fertility decline, a classic hallmark of the middle stage of demographic transition (Dissanayake, 1995).

Phase 3: Slowing Growth (1981–2024)

Population Change: 14.8 million → 21.76 million
Time Span: 43 years

Key Characteristics:

- **Annual Growth Rate:** Gradually declined to 0.5% by 2024.
- **Fertility Transition:**
    - Fertility began to decline due to increased access to education, contraception, women's empowerment, and urbanization.
    - Total Fertility Rate (TFR) dropped below replacement level (2.1) in several districts (Dissanayake, 2024)
- **Other Contributing Factors:**
    - Out-migration for employment (especially to the Middle East and Western countries),
    - Aging population: The proportion of elderly (60+) has significantly increased, reducing natural increase.
    - Economic constraints: Recent financial crises and uncertainty have also discouraged larger families.
    - Although the population continued to grow, the rate of growth plateaued.

This is the post-transition phase, where fertility and mortality are both low, and population growth levels off, matching the plateau stage of the logistic curve.

Data Sources

Population data were obtained from official national census figures provided by the Department of Census and Statistics, Sri Lanka, including:

- Historical census data (1871–2024)
- Preliminary 2024 Census Report

Three different time frames were used:

- **Scenario 1**: 1871–2024 (full dataset)
- **Scenario 2**: 1981–2024 (recent decades)
- **Scenario 3**: 1871–2012 (excluding 2024)

Model Specification

This study employs a comparative demographic modeling approach to estimate Sri Lanka's population carrying capacity under three distinct historical scenarios using the logistic growth model. The logistic model is particularly suitable for population studies as it accounts for an initial phase of exponential growth followed by a slowing rate as the population approaches a theoretically upper limit (carrying capacity, K).

The logistic growth model is used to estimate population over time:

$$P(t) = \frac{K}{1 + Ae^{-rt}}$$

Where:

- $P(t)$: Population at time t
- K: Carrying capacity
- A: Initial condition constant
- r: Intrinsic growth rate
- t: Time in years since the baseline (set as 1871 = t_0)

Estimation Techniques

- In all scenarios, K, A, and r were estimated simultaneously using Nonlinear Least Squares (NLS) to obtain the best-fitting logistic curve (Seber & Wild, 2003).
- Estimation was performed using Python's SciPy library with the *curve_fit* function and additional optimization techniques to ensure convergence and minimize residuals (Virtanen et al., 2020).

Goodness-of-Fit Evaluation

The coefficient of determination (R^2) was computed to assess how well the model fits the observed data:

$$\boxed{R^2 = 1 - \frac{\sum(P_{\text{obs}} - P_{\text{pred}})^2}{\sum(P_{\text{obs}} - \bar{P}_{\text{obs}})^2}}$$

- Values close to 1.0 indicate a strong fit between the model and the observed population values.
- Residual analysis and visual inspection of fitted vs. observed data were also used to validate results (Keyfitz and Caswell, 2005).

To understand how different historical contexts influence estimates of carrying capacity, the study evaluates three separate scenarios:

Scenario 1: Long-Term Historical Projection (1871–2024)

This scenario uses census data from 1871 to 2024, encompassing over 150 years of population dynamics, including colonial, post-independence, and modern periods. This scenario aims to capture the full trajectory of demographic transition and long-run potential.

Scenario 2: Post-Liberalization Period (1981–2024)

The second scenario focuses solely on the post-1981 period, which marks the beginning of significant economic liberalization and the onset of fertility decline in Sri Lanka. This scenario reflects current demographic conditions and is used to assess how closely the population is nearing stabilization under contemporary socioeconomic patterns.

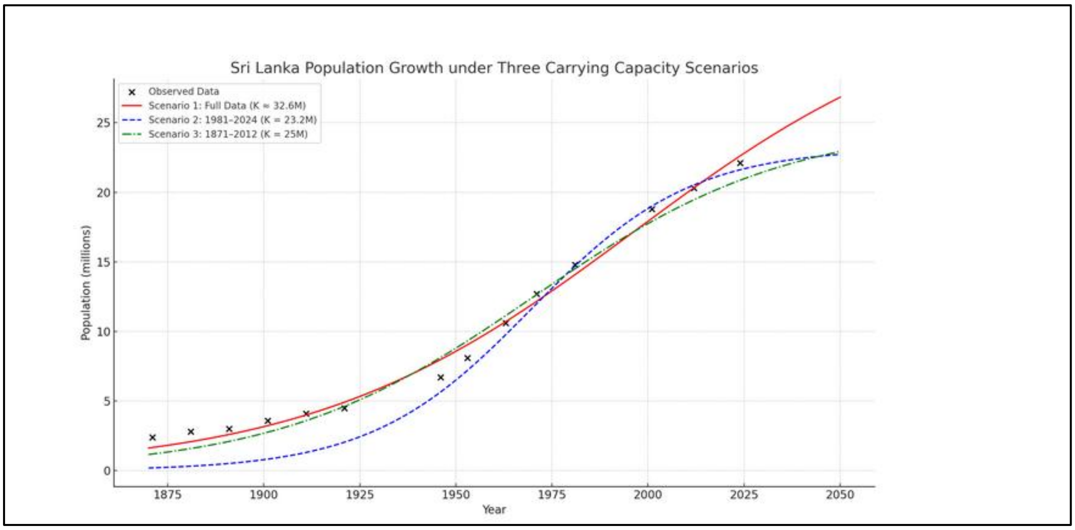
Scenario 3: Pre-Stagnation Historical Trend (1871–2012)

The third scenario uses data from 1871 to 2012, deliberately excluding the post-2012 period, which has seen a marked deceleration in population growth. This model serves to identify whether the slowdown observed after 2012 represents a temporary deviation or a structural shift in demographic trajectory.

Results and Discussion

Figure 3 illustrates the application of the logistic growth model to Sri Lanka's population trajectory from 1871 to 2024, under three different scenarios for the carrying capacity (K), which represents the maximum sustainable population size the country can support. The logistic model is well-suited for this type of demographic analysis because it captures the nonlinear nature of population growth, which typically starts slowly, accelerates during the mid-phase due to favorable conditions, and eventually decelerates as limiting factors—such as resource constraints, economic pressures, and spatial limitations—begin to take effect. In this context, the figure presents three scenarios, each based on a different estimated value for K, to explore how varying assumptions about long-term sustainability influence the trajectory of population growth. By fitting the model to historical census data, these curves allow for a comparative analysis of how soon the population may reach a point of saturation and what future stability might look like. This helps policymakers, planners, and researchers better understand potential demographic ceilings and prepare for the socio-economic implications of a stabilizing or aging population.

Figure 3: Logistic Growth Model Fit to Sri Lanka Population under Three Carrying Capacity Scenarios ,1871 -2024



Source: Based on Author's calculations

Scenario 1: Full Dataset (1871–2024)

- Carrying Capacity (K): 32.6 million
- Growth Rate (r): 0.0238
- Initial Ratio (A): 19.60
- R^2 Value: 0.9912
  (This indicates an excellent model fit to the entire observed dataset.)

This scenario uses complete historical data from 1871 to 2024. The model estimates a relatively high K of 32.6 million, the highest among all three scenarios. The excellent R^2 value (0.9912) suggests the model fits the entire dataset very well. However, this high K may overstate future potential, especially considering recent signs of slowing growth. This model assumes long-term stability and gradual approach to saturation, which may not fully reflect current demographic realities such as aging, migration, or reduced fertility rates.

Scenario 2: Recent Data (1981–2024)

- Carrying Capacity (K): 23.2 million
- Growth Rate (r): 0.0481
- Initial Ratio (A): 0.578
- R^2 Value: 0.9885
  (Also a very good fit but based only on recent slower-growth decades.)

This scenario focuses only on recent decades characterized by slower population growth, post-demographic transition. K is at a conservative 23.2 million based on trends after 1981. The model yields a higher growth rate ($r = 0.0481$) due to the shorter timeframe and a much lower A value, indicating a flatter sigmoid curve nearing saturation. The R^2 is still strong, suggesting the model adequately captures the recent dynamics. However, it lacks historical context and may underestimate long-term capacity if conditions change (e.g., economic recovery, migration).

Scenario 3: Historical Data (1871–2012)

- Carrying Capacity (K): 25 million
- Growth Rate (r): 0.0301
- Initial Ratio (A): 19.88
- R^2 Value: 0.9785
  (A strong fit up to 2012 but diverges after due to lower actual growth.)

This scenario excludes the 2024 preliminary census data, using only the period up to 2012. It reveals a moderate K of 25 million. The model fits the pre-2024 data well but diverges from observed trends thereafter, particularly due to slower-than-expected growth between 2012 and 2024. The R^2 is still relatively high but the lowest among the three, indicating some limitations in predictive accuracy for recent years. This scenario offers a balance between the optimistic projection of Scenario 1 and the conservative limits of Scenario 2.

Residual Analysis Results

Scenario 1: 1871–2024

- Root Mean Square Error (RMSE): 0.6564
- Mean Absolute Error (MAE): 0.5725

Scenario 2: 1981–2024

- Root Mean Square Error (RMSE): 0.0071
- Mean Absolute Error (MAE): 0.0062

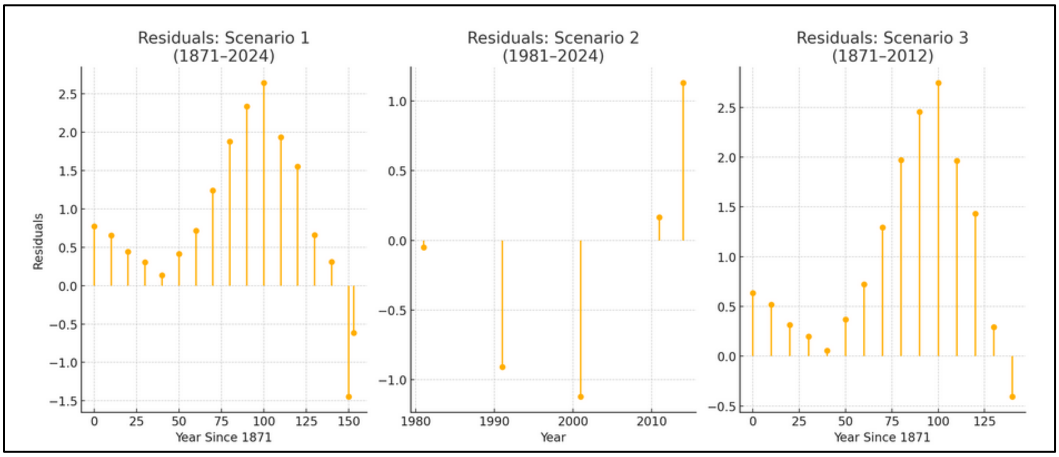
Scenario 3: 1871–2012

- Root Mean Square Error (RMSE): 0.6103
- Mean Absolute Error (MAE): 0.5202

These values demonstrate a very good fit, particularly in Scenario 2 (1981–2024), where both RMSE and MAE are extremely low, indicating minimal deviation from observed data.

The following are the residual plots for the three logistic growth scenarios:

Figure 4: Residual Analysis Results



Source: Based on Author's' Calculations

- **Scenario 1 (1871–2024)**: Shows some variation in earlier and recent years, but residuals remain reasonably small, indicating a good overall fit.
- **Scenario 2 (1981–2024)**: Residuals are minimal and tightly clustered around zero, confirming an excellent fit and model reliability.
- **Scenario 3 (1871–2012)**: Slightly higher deviations in mid-20th-century data, but residuals are still within acceptable bounds, suggesting a valid model fit up to 2012.

These visualizations support the earlier conclusion that Scenario 2 offers a very good statistical fit for the observed data.

Table 2 presents a comparative summary of three logistic growth model scenarios applied to Sri Lanka's population data, based on varying time spans and assumptions about future growth. Each scenario estimates the carrying capacity (K), intrinsic growth rate (r), and model fit (R^2), providing insights into different perspectives on population dynamics. The full dataset scenario (1871–2024) yields the highest K and best model fit, reflecting an optimistic outlook but potentially overestimating long-term growth. The second scenario, using only recent data (1981–2024), projects a lower K with a higher growth rate, capturing short-term trends while overlooking historical context. The third scenario, based on data up to 2012, offers a more balanced projection, though it may not fully account for the slower population growth observed in the last decade. This comparison helps assess the implications of different modeling approaches for demographic forecasting.

Table 2: Key Comparison of the three Scenarios

Scenario	Time Span	Carrying Capacity (K)	Growth Rate (r)	R^2	Notes
1. Full Dataset until 2024	1871–2024	32.6 million	0.0238	0.9912	Best fit; optimistic; may overestimate future potential
2. Recent Only 1981 to 2024	1981–2024	23.2 million	0.0481	0.9885	Realistic short-term; ignores historical growth pattern
3. Historical Only up to 2012	1871–2012	25 million	0.0301	0.9785	Balanced; diverges from post-2012 slower growth

From Growth to Resilience

The results show that Sri Lanka has transitioned from a phase of rapid population growth marked by high fertility rates and expanding youthful cohorts into an era of demographic maturity. The population trajectory is now characterized by slower growth, declining fertility, population aging, and increasing urbanization. The evidence from logistic modeling confirms that the country is approaching, or may have already reached, its effective demographic carrying capacity.

This shift has profound implications. Demographic expansion is no longer the driving force of economic and social change. Instead, demographic quality, the composition, health, skills, and productivity of the population is emerging as the key factors that will define Sri Lanka's future.

Implications of the Transition

1. From Quantity to Quality:
   Investments must now focus not on preparing for more people, but on equipping a smaller, aging, and more diverse population with the tools to thrive — such as education, healthcare, digital inclusion, and social protection.

2. From Expansion to Adaptation:
   Infrastructure, housing, and public services must be re-evaluated through the lens of stable or declining population sizes, especially in rural and estate sectors where depopulation may intensify.

3. From Young to Aging Society:
   As the elderly population increases in both absolute and relative terms, new frameworks for elder care, pension reform, and age-friendly economic participation are critical. The burden on the working-age population will intensify unless productivity improves significantly.

4. From Migration Outflows to Policy Levers:
   Rising emigration, especially of youth and skilled labor, challenges domestic labor markets. Migration policy must shift from containment to strategic engagement, including circular migration, diaspora integration, and returnee reintegration.

5. From Growth-centric to Sustainability-centric Development:
   With resource constraints and environmental limits more visible, development planning must now prioritize ecological balance, urban sustainability, and resilience to shocks - be they economic, climate-related, or epidemiological.

This demographic turning point demands a paradigm shift in policymaking away from legacy growth models and toward adaptive governance that embraces long-term resilience, inclusivity, and intergenerational equity. Sri Lanka's future prosperity will not be measured by how many people it has, but by how well it prepares them to live meaningful, healthy, and productive lives in a rapidly changing world.

Why It Fits Sri Lanka:

1. S-Curve Pattern Evident in Historical Data

- The gradual rise (1871–1946) → exponential surge (1946–1981) → flattening growth (1981–2024) is almost textbook logistic behavior.

- The sigmoid or S-shape seen in this population data is a key assumption of the logistic model.

Approaching Carrying Capacity

- A logistic model assumes population will stabilize when environmental, economic, and social limits restrict further growth.
- Sri Lanka’s population growth has slowed to 0.5%, and only 1.4 million people have been added between 2012 and 2024.
- The Total Fertility Rate has dropped below replacement, and life expectancy has increased, pointing to a shift toward population aging, not expansion.
- This stagnation suggests Sri Lanka is nearing its demographic ceiling, consistent with the upper asymptote of a logistic curve (K).

Demographic Transition Theory Alignment

- Logistic growth reflects the natural arc of demographic transition.
- Sri Lanka's shift from high birth/death rates to low birth/death rates fits within this framework, reinforcing the use of logistic models as valid predictors.

The logistic model offers a statistically and demographically robust framework for Sri Lanka’s population projections. The three clearly distinguishable historical phases align with the model's assumptions of slow–fast–slow growth, and current indicators suggest the population is approaching a plateau. These features make logistic modeling particularly suitable for future planning, especially when refined with context-aware methods as done in Lakshman Dissanayake’s hybrid projection models.

Sri Lanka’s demographic journey over the past 150 years presents a compelling case of a nation transitioning through the full arc of the demographic cycle marked by high birth and death rates in the pre-modern era, rapid growth during development phases, and the onset of population stabilization in the modern period. To capture the intricacies of this transition and to inform sustainable demographic planning, this study applied the logistic growth model, a classical tool in population ecology and demography, under three carefully designed scenarios. Each scenario offers a unique lens through which Sri Lanka's population dynamics can be understood and projected.

Scenario-Based Insights: Modeling the Past, Present, and Future

Scenario 1 (1871–2024): The Long Arc of Population Growth

This scenario incorporates the full breadth of Sri Lanka's recorded demographic history from the 1871 colonial census to the 2024 preliminary census. The model estimates a carrying capacity (K) of 32.63 million, suggesting a long-term theoretical ceiling based on historical momentum. The model fits well ($R^2 = 0.9912$), indicating that logistic growth appropriately describes the population trend over time. However, given the notable slowdown in population growth since 2012 and the current 2024 population of 21.76 million, this upper-bound projection may now overestimate the population Sri Lanka is likely to support under current economic, fertility, and migration conditions.

Scenario 2 (1981–2024): Post-Liberalization and Fertility Decline

Focusing on the period following Sri Lanka's economic liberalization and demographic transition, this scenario adopts a fixed K of 23.2 million. With a very good model fit ($R^2 = 0.988$), it closely aligns with contemporary demographic behavior, including declining fertility (currently below replacement level), increasing life expectancy, and net migration losses. This model suggests population stabilization around 2025–2030, making it the most realistic and policy-relevant scenario. It underscores that Sri Lanka has likely reached or is very near its demographic peak, shifting the planning challenge from managing growth to managing stability and decline.

Scenario 3 (1871–2012): Growth Momentum Interrupted

Excluding the post-2012 stagnation period, this model assumes that pre-2012 trends would have continued uninterrupted, placing the carrying capacity at 25.0 million. While historically grounded ($R^2 = 0.978$), this projection fails to account for the abrupt post-war fertility decline, increased youth outmigration, and economic constraints. It serves as a useful counterfactual to highlight how recent shifts have diverged from long-standing growth trajectories.

Key Insights and Diverging Trajectories

The three scenarios reveal that while logistic growth remains a valid model across time, the assumed carrying capacity and policy context dramatically influence projected outcomes. Importantly, the timing at which each scenario predicts population stabilization varies:

- Scenario 1 projects continued growth until mid-century (2045–2050), contingent on older assumptions.
- Scenario 2 identifies a near-term stabilization within the next five years, in line with 2024 data.
- Scenario 3 suggests stabilization around 2035, indicating continued growth but at a moderated pace.

This divergence underscores the importance of aligning demographic models with up-to-date data and contemporary socioeconomic realities.

Policy Implications and the Path Forward

The implications of this analysis are profound. With population growth nearly plateauing, Sri Lanka must pivot from planning for expansion to preparing for demographic stability and eventual decline. Priorities must include:

- Investing in an aging population through health, social protection, and long-term care systems.
- Mitigating youth outmigration by creating local opportunities, especially in knowledge-based industries.
- Fostering gender equity and family support systems to stabilize fertility at sustainable levels.
- Planning for labor force transitions with an emphasis on productivity, skill development, and automation.

The window for proactive policy action is narrow. Unlike earlier decades that focused on fertility control and urban service expansion, the next phase must emphasize demographic quality, resilience, and sustainability. Scenario 2 provides a particularly urgent call to action: with only a narrow demographic cushion left, inaction could result in aging without preparedness, a demographic trap already seen in parts of East Asia and Eastern Europe.

Conclusion

This study employed a scenario-based logistic growth modeling framework to examine Sri Lanka's population dynamics over a 150-year period, with the objective of understanding historical trends, estimating carrying capacity, and deriving implications for sustainable demographic planning. By applying the logistic growth model under three distinct scenarios (1) 1871–2024 with an estimated carrying capacity (K) of 32.6 million, (2) 1981–2024 with 23.2 million, and (3) 1871–2012 with 25.0 million the analysis provides valuable insights into the country's demographic trajectory, transition, and potential future stability.

Each scenario captures a specific phase of Sri Lanka's demographic evolution: the full historical arc of population expansion (Scenario 1), the post-demographic transition period characterized by fertility decline and economic restructuring (Scenario 2), and a counterfactual projection assuming continued historical growth momentum until 2012 (Scenario 3). These perspectives collectively highlight the importance of contextualizing demographic models within the socio-economic and policy environments in which population changes occur.

The results suggest that Sri Lanka is now at or near its population stabilization point. The most recent data from the 2024 Preliminary Census report a population of 21.76 million, aligning most closely with Scenario 2, which assumes a lower and more realistic carrying capacity of 23.2 million. This suggests that the long-anticipated demographic transition has effectively reached maturity. With an R^2 value of 0.988, Scenario 2 emerges as a statistically robust and demographically plausible model, capturing the slow population growth, below-replacement fertility, increasing out-migration, and urban-rural differentials that characterize the present demographic context.

Importantly, the three scenarios reach their asymptotic stability points at different time horizons, underscoring the influence of both historical inertia and recent accelerators of demographic change, such as economic crises, shifting social norms, and migration dynamics. Scenario 1 extends growth far into the mid-21st century, which appears less consistent with current demographic indicators, while Scenario 3 suggests moderate growth into the 2030s. Scenario 2, however, indicates that Sri Lanka has entered a phase of demographic stability and may be approaching population decline in the coming decades.

This study demonstrates that demographic modeling, when approached with historical depth and scenario-based reasoning, can serve as a valuable instrument for evidence-informed planning. The logistic growth model, despite its simplicity, offers a useful framework for understanding the complex interplay between population, resources, and policy. Sri Lanka's experience provides important insights for other middle-income countries approaching demographic maturity.

As the country navigates this new chapter, the focus must now shift from managing growth to managing sustainability, ensuring that demographic transitions are met with adaptive governance, equitable development, and long-term resilience. Sri Lanka’s population journey, viewed through this 150-year lens, is not merely a narrative of numbers; it is also a story of choices, transformations, and the need to align planning with demographic realities.

References

Abeykoon, A. T. P. L. (1995). *Population and manpower resources in Sri Lanka, 1995–2030*. Institute of Policy Studies.

Caldwell, J. C. (1986). *Routes to low mortality in poor countries*. Population and Development Review, 12(2), 171–220. https://doi.org/10.2307/1973108

Department of Census and Statistics. (2025). *Preliminary report: Census of population and housing 2024*. Department of Census and Statistics.

De Silva, S. (1994). *Population and labour force projections for Sri Lanka, 1991–2031*. Ministry of Finance, Planning, Ethnic Affairs and National Integration.

De Silva, W. I. (2007). *A population projection for Sri Lanka for the new millennium, 2001–2101: Trends and implications*. Institute for Health Policy.

De Silva, W. I., & de Silva, R. (2015). *Sri Lanka: 25 million people and implications*. United Nations Population Fund.

Dissanayake, L. (1995). *The influence of education on the fertility transition in Sri Lanka* (Doctoral dissertation, University of Adelaide).

Dissanayake, L. (2009). *Making the connection: Population dynamics and development in Sri Lanka*. United Nations Population Fund & Ministry of Finance and Planning.

Dissanayake, L. (2014). *Medium-term population projection for Sri Lanka: 2012–2037*. United Nations Population Fund.

Dissanayake, L. (2024). *The influence of COVID-19 pandemic on fertility: The case of Sri Lanka*. United Nations Population Fund.

Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography* (3rd ed.). Springer.

Seber, G. A. F., & Wild, C. J. (2003). *Nonlinear regression*. Wiley-Interscience.

United Nations, Department of Economic and Social Affairs, Population Division. (2023). *World population prospects 2022: Summary of results*. United Nations. https://www.un.org/development/desa/pd/content/world-population-prospects-2022

Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., et al. (2020). SciPy 1.0: Fundamental algorithms for scientific computing in Python. *Nature Methods, 17*(3), 261–272. https://doi.org/10.1038/s41592-019-0686-2