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Population Projection Based on the Cohort-Component Method: A Comparative Study of Global and Indonesian Approaches

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Abstract
This study aims to examine the population growth projections of Indonesia and the world for the period 2020–2050 using the cohort-component method. It also compares the projection approaches used by Statistics Indonesia (BPS) and the United Nations (UN), and evaluates the strengths and limitations of the method in both national and global contexts. The research was conducted through a review of official projection documents, descriptive analysis of demographic trends (population size, TFR, births, deaths, and migration), and methodological evaluation based on technical documentation. The findings indicate that both Indonesia and the world are experiencing declining population growth rates and fertility levels through 2050, although Indonesia is projected to maintain positive growth. BPS employs a deterministic approach using policy-based scenarios, while the UN adopts a probabilistic, Bayesian-based approach. The evaluation reveals that the cohort-component method offers advantages in age structure accuracy and application flexibility, yet it also has limitations related to assumptions and reliance on data quality. These findings highlight the importance of adaptive approaches in demographic projections to support data-driven development planning.

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Keywords: Population Projection, Cohort-Component Method, Birth, Death, Migration, Population Growth, United Nations, BPS

Introduction

Population projection is one of the essential instruments in medium- and long-term development planning of a country. It not only provides estimates of future population size, but also the age structure, sex composition, and spatial distribution. This information is crucial in designing policies across key sectors such as education, health, employment, housing, and infrastructure. Without accurate projections, development efforts risk being misaligned with actual demographic needs and may fail to respond to future population dynamics (United Nations, n.d.; BPS, 2023) [1, 2].

According to the United Nations (UN), a population projection is an estimate of the future size and structure of the population, based on historical demographic data and assumptions regarding the evolution of fertility, mortality, and migration. Its primary purpose is to provide an analytical foundation for evidence-based policy and sustainable planning (United Nations, 2019) [3]. In Indonesia, population projections are officially conducted by Statistics Indonesia (Badan Pusat Statistik, BPS) and are used to support development planning at both the national and subnational levels, from provinces down to regencies and municipalities (BPS, 2023; BPS, 2023) [2, 4].

The most commonly used method by both the UN and BPS is the cohort-component method, which is the international standard for population projections. This method estimates changes in population over time by separately accounting for the contributions of the three main demographic components: births, deaths, and migration. These changes are tracked for each age group and sex, resulting in a detailed and dynamic projection of the population structure (United Nations, 1984; BPS, 2023) [5, 2]

Since 2014, the United Nations has adopted a probabilistic approach based on Bayesian hierarchical models, replacing the earlier deterministic approach using fixed variants. This probabilistic model produces median estimates along with 80% and 95% credible intervals, reflecting the uncertainty in demographic variables (Alkema *et al*., 2015; United Nations, 2019) [6, 3]. Projections are based on thousands of simulations per country, thereby capturing a wide range of plausible demographic trajectories (United Nations, n.d.; Vollset *et al*., 2023) [1, 7].

BPS also applies the cohort-component method with a combination of deterministic and probabilistic approaches. Official projections are generated using the deterministic approach, while the probabilistic method is employed for quality assurance, using Bayesian population projection techniques (BPS, 2023; FMS Indonesia, 2023) [2,8]. This combined approach allows BPS to produce adaptive projections that can be statistically validated.

In the Indonesia Population Projection 2020-2050 report, BPS outlines three projection scenarios: trend, moderate, and optimistic. The trend scenario represents the continuation of past demographic patterns, while the moderate and optimistic scenarios reflect assumptions of accelerated development and policy interventions. Key demographic assumptions in these scenarios include the Total Fertility Rate (TFR), Infant Mortality Rate (IMR), and life expectancy (BPS, 2023) [2].

Fertility is projected using logistic functions based on historical data and development targets, while mortality is projected through reductions in IMR and increases in life expectancy, reflecting past improvements in national health outcomes (BPS, 2023; United Nations, 2024) [2,9]. Migration both internal and international is projected based on age-specific patterns derived from population census and intercensal surveys (BPS, 2023; United Nations, n.d.) [2,10].

Special adjustments are made in migration projections for regions affected by the development of the new capital city (Ibu Kota Negara/IKN), such as DKI Jakarta, West Java, Banten, and East Kalimantan. Internal migration projections are aligned with Presidential Regulation No. 63 of 2022, which governs the relocation of the national capital and civil service apparatus to East Kalimantan (BPS, 2023; FMS Indonesia, 2023) [2,8]. These adjustments reflect the model's sensitivity to long-term national policies.

Based on this background, this article aims to empirically examine the application of the cohort-component method in population projections conducted by the United Nations and Statistics Indonesia (BPS). By comparing the approaches adopted at the global and national levels, this study seeks to provide a deeper understanding of the strengths, flexibility, and limitations of the cohort-component method. Such an evaluation is essential for assessing the reliability of population projections as a planning tool and for ensuring appropriate policy responses to national and global demographic dynamics.

Methods

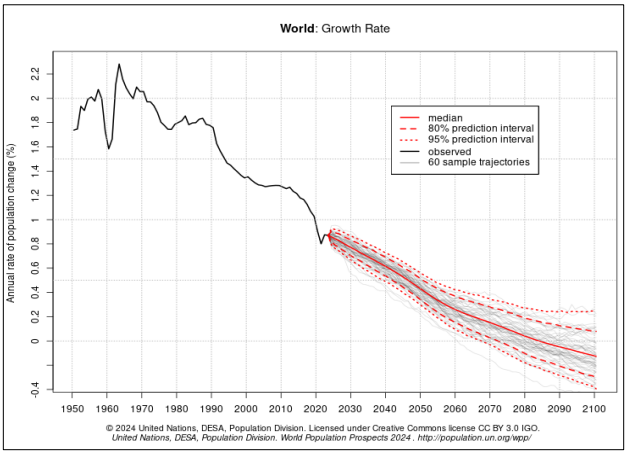
This study is a descriptive-quantitative research based on a literature review, utilizing data and findings from official international and national sources, namely Statistics Indonesia (BPS) and the United Nations (UN). For Indonesia, the data were obtained from BPS publications such as Indonesia Population Projection 2020-2050 based on the 2020 Population Census. For the global scope, the study used the World Population Prospects 2024 report published by the United Nations Department of Economic and Social Affairs (UN DESA) and Population Division, as well as supporting databases available on the official UN World Population

Prospects (UN WPP) website. The procedure for this study is as follows:

1. Data Collection: collecting official population projection results from BPS (Indonesia) and UN (global), including methodological documents and supporting visual materials.
2. Methodological Review: examining the projection methods used by BPS and UN, including deterministic and probabilistic approaches, and the assumptions regarding fertility, mortality, and migration.
3. Projection Analysis: analyze demographic trends and positions for both Indonesian and global data during the 2020-2050 period based on official projection results.
4. Method Evaluation: assessing the strengths and limitations of the cohort-component method in both global and national contexts from technical and policy perspectives.
5. Conclusion Formulation: formulating conclusions based on the comparison of projection results and evaluation of methods to address the research problem.

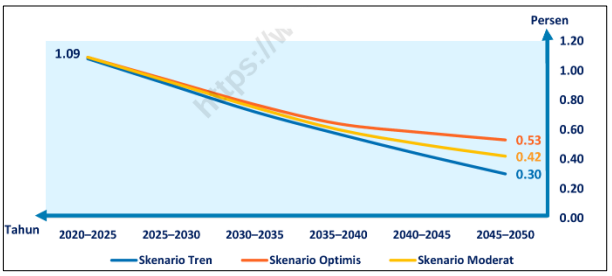
Results and Discussion

1. Comparison of Projected Population Growth Rates: Global and Indonesia (2020-2050)



Source: UN DESA, World Population Prospects 2024

Fig 1: Projected Global Population Growth Rate, 2020-2050



Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

Fig 2: Indonesia's Projected Population Growth Rate, 2020-2050

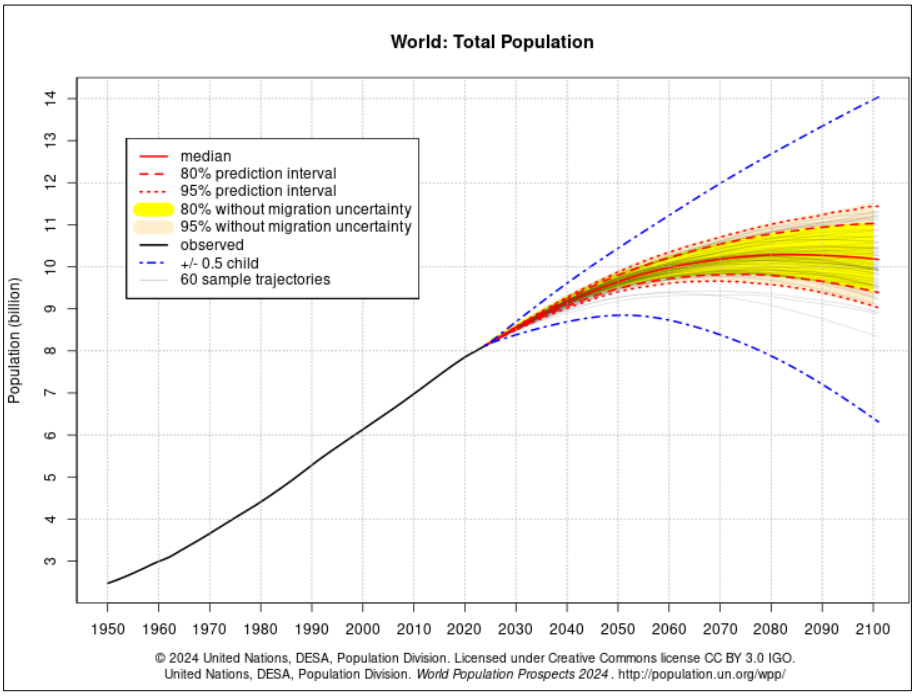
Figure 1 presents the projected global population growth from 1950 to 2100 by the UN, which shows a consistent downward trend from just above 1% to around 0.5% or lower by 2050. The 80% and 95% prediction intervals indicate uncertainty, but overall, they still point to a declining trend.

This decline may be influenced by various global factors such as decreasing birth rates, population aging, and increasing urbanization in many regions of the world.

Meanwhile, Figure 2 shows Indonesia's projected population growth from 2020 to 2050 by BPS under three scenarios. In 2020, Indonesia's population growth rate was 1.09%. All scenarios show a gradual decline in growth rates. By the end of the 2045-2050 period, the projected rates are 0.30% (trend scenario), 0.42% (moderate scenario), and 0.53% (optimistic scenario). These scenarios reflect anticipations of various possible population, socio-economic, and external policy dynamics influencing Indonesia's demographic trends.

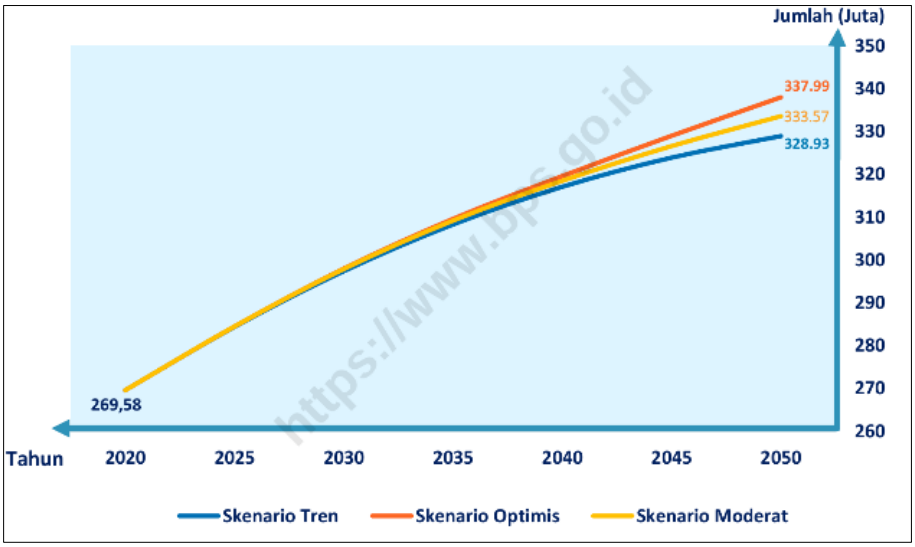
Overall, both global and Indonesian projections indicate a decline in population growth rates throughout 2020-2050. However, the global decline is expected to be sharper, approaching zero, while Indonesia is still projected to maintain positive growth. This indicates that Indonesia, at least until the mid-21st century, still has relatively higher demographic growth potential compared to the global average.

2. Comparison of the Projected Total Population: Global and Indonesia (2020-2050)



Source: UN DESA, World Population Prospects 2024

Fig 3: Projected Global Total Population, 2020-2050



Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

Fig 4: Indonesia's Projected Total Population, 2020-2050

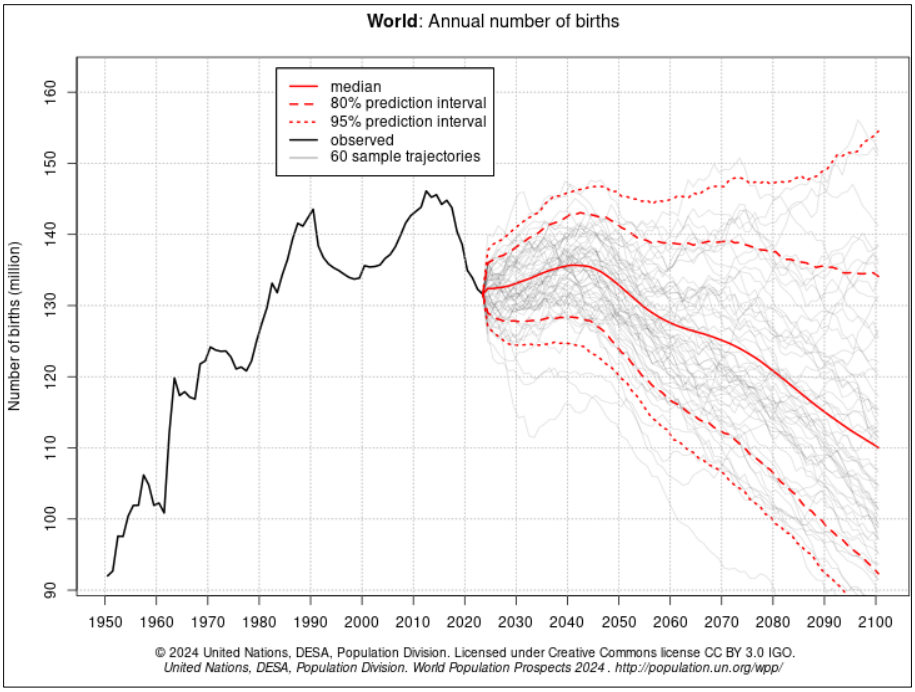
Figure 3 illustrates the historical trend (1950-2024) and probabilistic projections of the global population up to the year 2100. The historical data are represented by a black line, while post-2024 projections are shown using a probabilistic approach, including the median projection (red line) and 80% and 95% prediction intervals. In 2020, the global population

was recorded at approximately 7.9 billion and is projected to reach 9.5 billion by 2050. These projections highlight uncertainties arising from variations in fertility and migration, and indicate a potential slowdown in global population growth towards the end of the century, possibly leading to stagnation or even decline after 2080.

Meanwhile, Figure 4 presents population projections for Indonesia from 2020 to 2050, based on the 2020 Population Census. In 2020, Indonesia's population was recorded at 269.58 million, and is projected to increase to 328.93 million (trend scenario), 335.57 million (moderate scenario), and up to 337.99 million (optimistic scenario) by 2050. These projections use a deterministic approach without uncertainty intervals, based on varying assumptions regarding fertility, mortality, and migration.

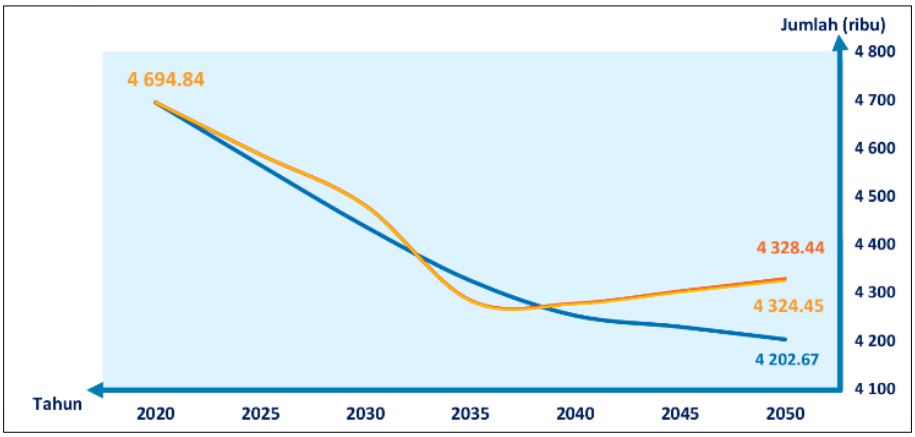
Both figures indicate an upward population trend between 2020 and 2050,with an estimated global growth of about 24%, and 22–25% for Indonesia depending on the scenario. Although they rely on similar demographic components, the methodologies differ: the global projection applies a probabilistic model to account for uncertainty, while the national projection employs a deterministic model tailored for policy planning. This methodological distinction reflects different objectives capturing global uncertainty versus informing national development planning. Both sets of projections serve as essential foundations for data-driven population policy.

3. Comparison of the Projected Number of Births: Global and Indonesia (2020-2050)



Source: UN DESA, World Population Prospects 2024

Fig 5: Projected Global Annual Number of Births, 2020-2050



Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

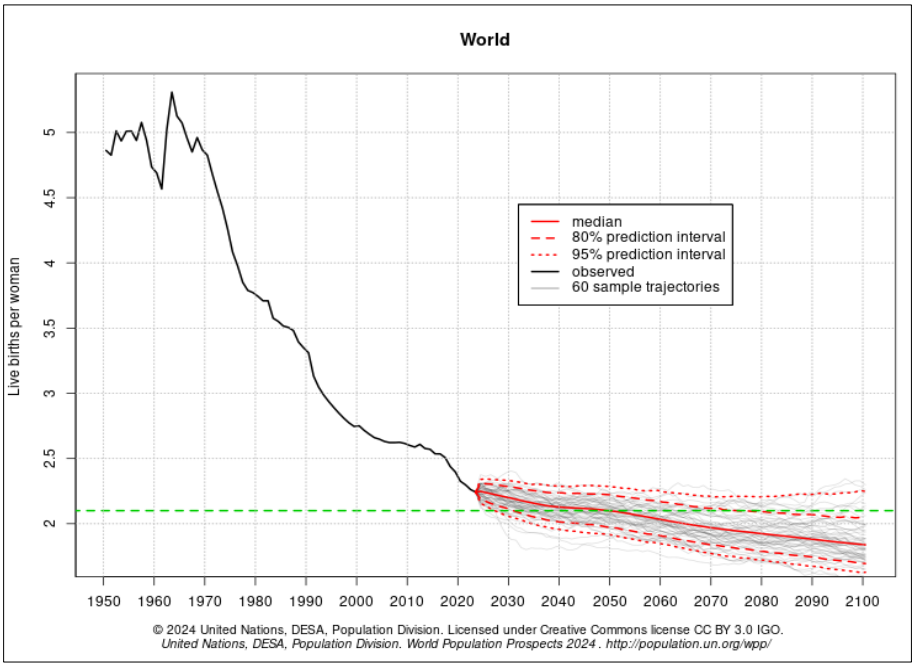
Fig 6: Indonesia's Projected Annual Number of Births, 2020-2050

Figure 5 presents the projected number of births globally from 1950 to 2100 based on the World Population Prospects 2024 published by the United Nations. In 2020, the global number of births was approximately 137 million and is projected to decline gradually to around 132-133 million by 2050, reflecting a decrease of about 3-4%. Meanwhile, Figure 6 shows Indonesia's projected annual number of births for the period 2020-2050, as estimated by Statistics Indonesia (BPS)

using three scenarios. In 2020, the number of births in Indonesia was about 4.694 million. All scenarios indicate a decline through 2035, followed by different trajectories: the trend scenario projects a continued decline to 4.203 million (−10.5%), the moderate scenario reaches 4.324 million (−7.9%), and the optimistic scenario shows a rebound to 4.328 million (−7.8%) by 2050.

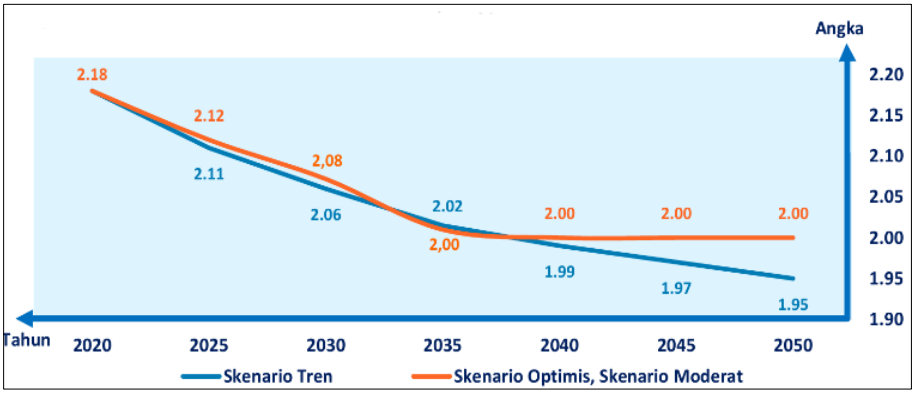
Overall, both global and Indonesian projections indicate a downward trend in annual births between 2020 and 2050. However, proportionally, the decline in Indonesia (7.8-10.5%) is steeper than the global average (3-4%), reflecting a more rapid fertility transition in Indonesia as a developing country entering the later phase of its demographic dividend.

4. Comparison of the Projected Total Fertility Rate (TFR): Global and Indonesia (2020-2050)



Source: UN DESA, World Population Prospects 2024

Fig 7: Projected Global Total Fertility Rate (TFR), 2020-2050



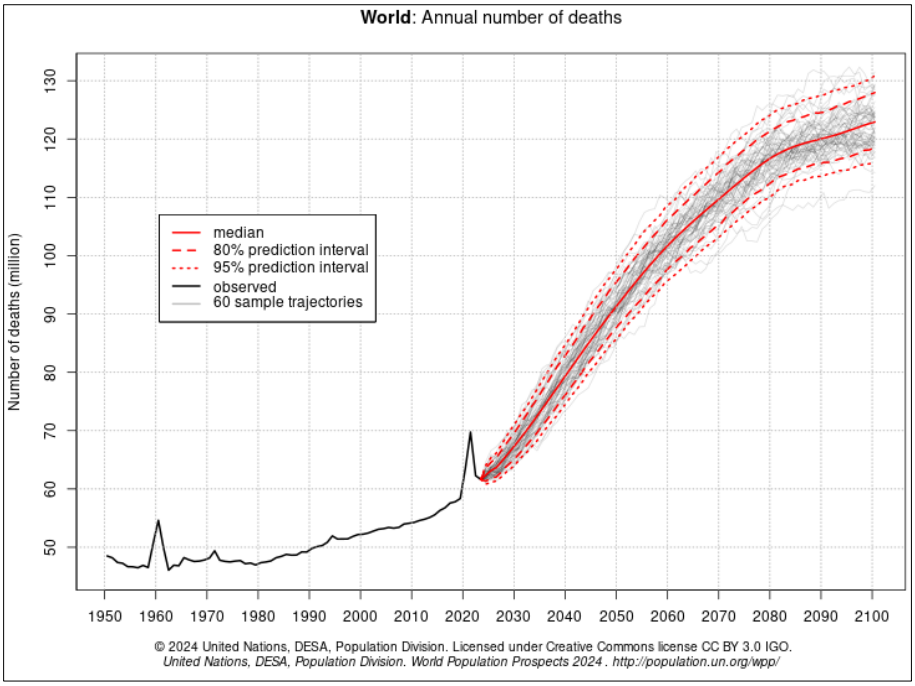
Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

Fig 8: Indonesia's Projected Total Fertility Rate (TFR), 2020-2050

Figure 7 illustrates the historical trend and projected global Total Fertility Rate (TFR) since 1950. The global TFR has declined sharply since the mid-20th century, reaching approximately 2.4 children per woman in 2020. Projections indicate a gradual decrease to around 2.1 by 2050, based on a probabilistic approach with 80% and 95% uncertainty intervals. This trend reflects a global shift toward sub-replacement fertility levels, which has significant implications for age structure and population growth dynamics.

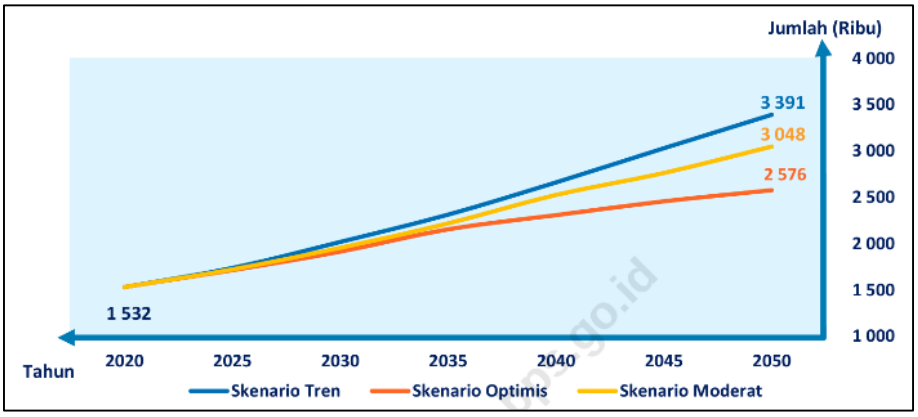
Meanwhile, Figure 8 shows Indonesia's TFR projections for 2020-2050 according to Statistics Indonesia (BPS). In 2020, Indonesia's TFR was recorded at 2.18 children per woman and is expected to decline to 1.95 (trend scenario) or remain stable at 2.00 (moderate and optimistic scenarios) starting in 2040. These projections are based on a deterministic approach with varying assumptions about the rate of decline. Overall, both global and Indonesian TFRs show a downward trend, though with different patterns. The global decline is steeper, while Indonesia's is more gradual and controlled, reflecting differing fertility transition dynamics between countries.

5. Comparison of the Projected Number of Deaths: Global and Indonesia (2020-2050)



Source: UN DESA, World Population Prospects 2024

Fig 9: Projected Global Number of Deaths, 2020-2050



Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

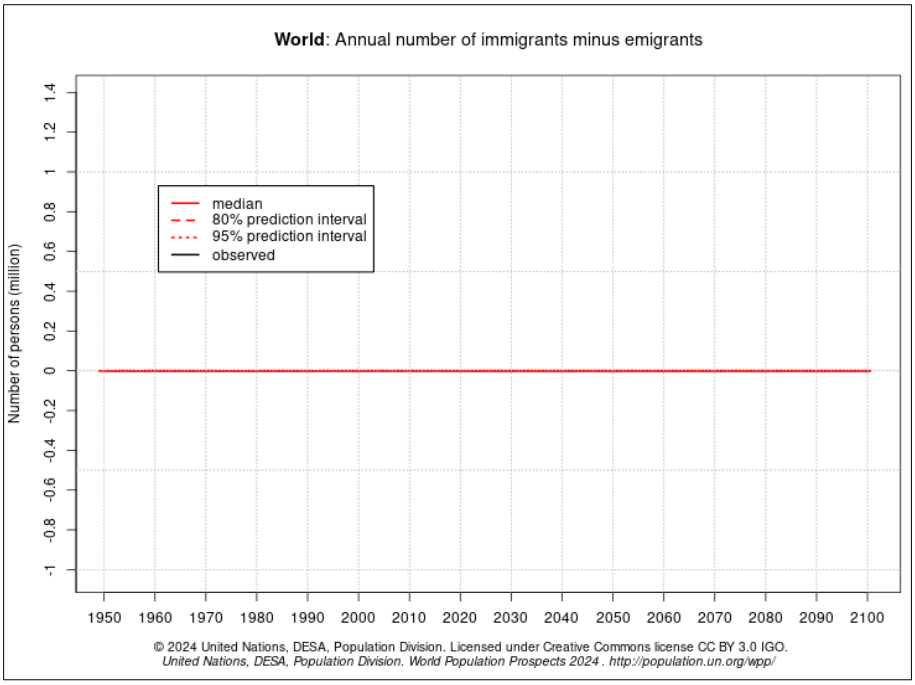
Fig 10: Indonesia's Projected Number of Deaths, 2020-2050

Figure 9 presents the projected number of deaths globally from 1950 to 2100 based on the World Population Prospects 2024 by the United Nations. In 2020, the global number of deaths was approximately 60 million and is projected to increase to around 90 million by 2050, representing a rise of about 50 percent. This increase reflects the ageing of the global population, particularly in countries that are further along in the demographic transition.

Meanwhile, Figure 10 displays Indonesia's projected number of deaths from 2020 to 2050 according to BPS. From 1.532 million in 2020, the annual number of deaths is projected to rise to 2.576 million (optimistic scenario), 3.048 million (moderate), and 3.391 million (trend) by 2050. This represents an absolute increase ranging from 1.044 to 1.859 million, or a proportional increase of 68 to 121 percent.

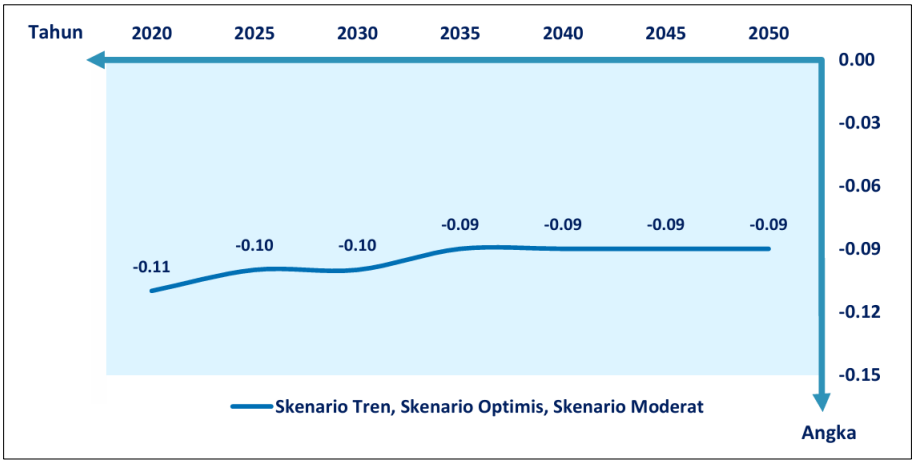
Overall, although the absolute number of deaths globally is significantly higher than in Indonesia, the proportional increase in Indonesia is notably greater. While the global annual number of deaths is projected to rise by about 50 percent from 2020 to 2050, Indonesia is expected to experience an increase of between 68 and 121 percent, depending on the scenario. This indicates that the annual growth rate of deaths in Indonesia is relatively faster than the global average. In general, both globally and in Indonesia, the demographic trajectory is similar as both move toward an ageing population era, marked by increasing numbers of annual deaths.

6. Comparison of the Projected Net Migration: Global and Indonesia, 2020-2050



Source: UN DESA, World Population Prospects 2024

Fig 11: Projected Global Net Migration, 2020-2050



Source: BPS, Proyeksi Penduduk Indonesia 2020-2050

Fig 12: Indonesia's Projected Net Migration, 2020-2050

Figure 11 displays the projected annual global net migration (immigrants minus emigrants) from 1950 to 2100. Focusing on the period from 2020 to 2050, the median line remains at zero, reflecting a global balance between the number of emigrants and immigrants. Since the world is considered a closed system, every person who emigrated from one country simultaneously immigrated to another, resulting in no net change in the total global population due to migration. Meanwhile, Figure 12 shows Indonesia's projected net migration for the period 2020-2050. The values are negative, declining from -0.11 per 1,000 population in 2020 to -0.09 starting in 2025, remaining constant through 2050 across all projection scenarios. This indicates that the number of people leaving Indonesia slightly exceeds those entering, although the scale of the difference is relatively small.

A comparison of the two figures illustrates that while migration has no net effect on global population growth, it can significantly influence national demographic dynamics. In Indonesia's case, the negative net migration contributes to slower population growth, particularly if not offset by sufficiently high fertility rates.

7. Identification of the Strengths and Limitations of the Cohort-Component Method

The cohort-component method is a standard and widely adopted approach for population projection, both globally and nationally. It models changes in population over time by accounting for the three main demographic components fertility, mortality, and migration disaggregated by age and sex (United Nations, 1984; BPS, 2023a) [5,2].

Strengths

This method is comprehensive and systematic, as it explicitly incorporates all key demographic components, allowing for a structured and accurate projection of population changes (Preston *et al.*, 2001; United Nations, 1984) [11, 5]. It is also

highly flexible, applicable at national, regional, and local levels, and thus valuable for multi-scale development planning (Siegel & Swanson, 2004; BPS, 2023) [12, 2]. The cohort-based structure is well-suited for long-term projections spanning 30-100 years (United Nations, 2019) [3], and it can be integrated with Bayesian probabilistic models to incorporate uncertainty, as implemented in the World Population Prospects since 2014 (Alkema *et al*., 2015) [6]. Furthermore, the model's demographic basis makes its results easily interpretable and policy-relevant (PAHO, n.d.; BPS, 2023) [13, 2].

Limitations:

The method's accuracy depends heavily on the quality and completeness of input data, particularly in terms of fertility, mortality, and migration, which are often lacking or inconsistent in many developing countries (Gerland *et al*., 2014; United Nations, 2024) [14,9]. Deterministic assumptions are limited in their ability to respond to sudden shocks such as pandemics, conflicts, or policy shifts (Vollset *et al*., 2023) [7]. Migration, especially international and internal flows, is highly uncertain and frequently the most difficult component to estimate (Rogers, 1995; United Nations, 2019) [15, 3]. Moreover, deterministic models typically produce single-point estimates without confidence intervals, in contrast to probabilistic approaches that provide prediction ranges (Alkema *et al*., 2015) [6]. Social and cultural dynamics such as shifting family norms, fertility preferences, or urbanization patterns are often not directly captured by the model's assumptions (Basten *et al*., 2013) [16]. Finally, projecting internal migration across regions poses additional complexity, especially in contexts with high population mobility, such as Indonesia's new capital development, which requires policy-based adjustments (BPS, 2023) [2].

Conclusion

Based on the analysis and discussion, it can be concluded that:

1. The cohort-component method used by both the United Nations (UN) and Statistics Indonesia (BPS) incorporates the three main demographic components: fertility, mortality, and migration, in projecting the population up to the year 2050. However, the two institutions employ different approaches. The UN adopts a probabilistic Bayesian-based approach, while BPS applies a deterministic method with trend, moderate, and optimistic scenarios.
2. Indonesia's population growth trend from 2020 to 2050 shows an increase in population size alongside a declining growth rate, a pattern that mirrors the global projection. Nonetheless, Indonesia is projected to maintain positive growth, while global population growth is expected to slow significantly and approach zero toward the end of the period.
3. Indonesia's fertility (TFR), birth, and death components exhibit more controlled trends compared to global patterns, with a steady decline in TFR and a proportionally sharper rise in mortality. While global migration projections tend to be neutral, Indonesia's net migration remains negative, contributing to the dynamics of population growth.
4. The cohort-component method offers several advantages, including accurate age-structure projections, flexibility for application across various geographic levels, and the ability to be integrated with probabilistic approaches. However, it also has limitations, such as high dependency on quality data, limited responsiveness to rapid social changes, and considerable uncertainty in migration forecasts.

Overall, the cohort-component method remains a relevant and reliable tool for demographic projection. Nevertheless, it should be complemented with adaptive approaches and ongoing validation efforts to ensure more precise and contextually grounded projection results.

Acknowledge

The author would like to express sincere gratitude to the Badan Pusat Statistik (BPS) and the United Nations Department of Economic and Social Affairs (UN DESA) for providing open and comprehensive population projection data for Indonesia and the world. Without the availability of such transparent data and projection methodologies, the comparative analysis presented in this article would not have been possible. Appreciation is also extended to previous researchers who have developed the cohort-component method, both deterministic and probabilistic, which served as a fundamental basis for this study. It is hoped that this article contributes to the growing body of literature on demographic dynamics and data-driven development planning, and serves as a useful reference for future research and policymaking that are responsive to upcoming demographic challenges.

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