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Balancing Growth and Sustainability: Exploring the Optimal Global Population

Jiaying Du[1]

[1] Pegasus California School, China
Correspondence: Jiaying Du, Pegasus California School, China.

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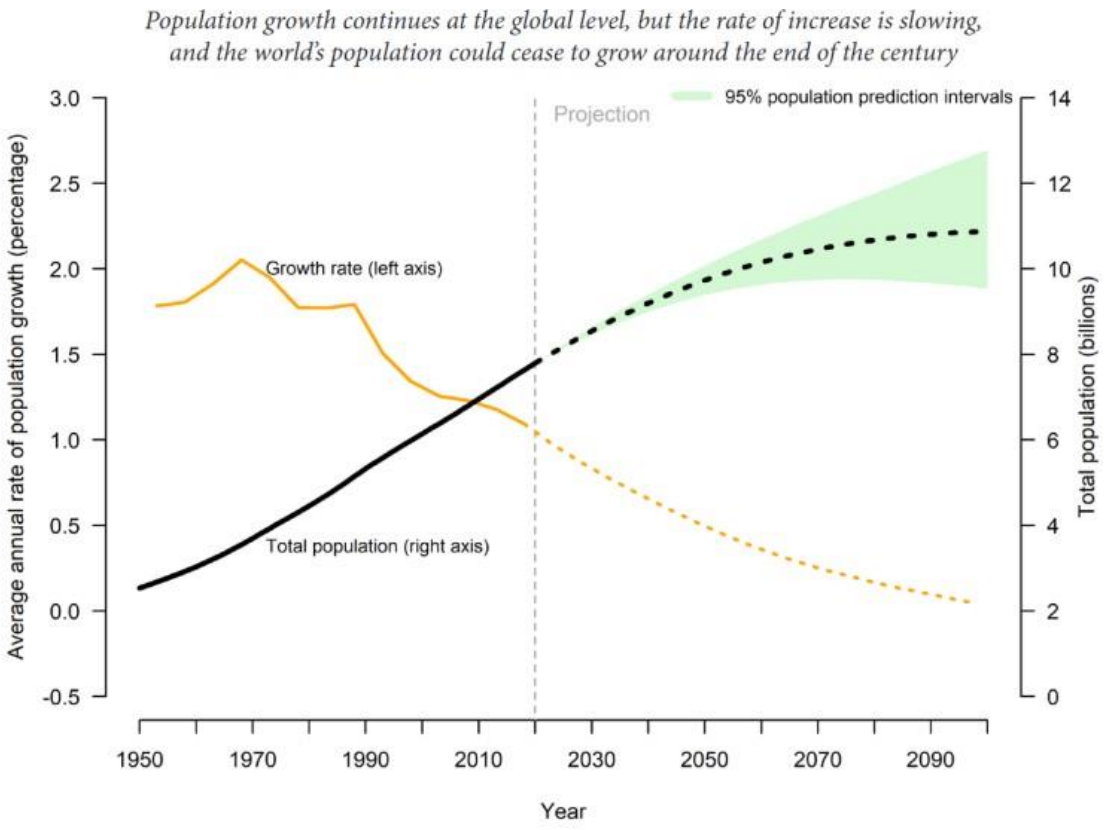
Abstract

This essay examines the implications of global population growth on sustainability and human development in the context of contemporary environmental challenges. With projections indicating a rise to 10.9 billion by 2100, concerns over resource scarcity and climate change intensify. The analysis utilizes the "IPAT" framework to explore how population size, affluence, and technology interact to shape environmental impacts. Historical perspectives, including Malthusian theory and the Green Revolution, are reviewed to assess their relevance in understanding current trends. Advances in agriculture, health sciences, and technology are highlighted as mitigating factors that challenge traditional notions of population limits. The essay concludes by discussing policy implications for achieving an "optimal" global population that balances sustainable development with improved living standards and environmental stewardship.

Keywords: population growth, sustainability, environmental impacts, technological advancements, policy implications

According to recent reports from the United Nations, the world's population has reached 8.1 billion in 2024 and is projected to reach approximately 8.5 billion by 2030, 9.7 billion by 2050, and 10.9 billion by 2100. These projections raise concerns about planetary sustainability (United Nations, 2022). Climate change exacerbates issues like resource scarcity, with the Food and Agriculture Organization warning of shortages in arable land and freshwater (Food and Architecture Organization, 2013). The "IPAT" framework, which considers population size (P), affluence (A), and technology (T), helps analyze these impacts. The IPCC stresses the need to limit global warming to 1.5°C by reducing 45 percent of the carbon dioxide emissions from 2010 levels by 2030 and achieving net-zero emissions by 2050 (Berwyn, Bob, 2018). Stabilizing or reducing the human population is crucial for long-term survival of all species on Earth.



Data source: United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019.*

Figure 1.

Defining the 'optimal' global population is highly complex due to significant variations in cultural, religious, economic, and environmental factors across regions. This definition must encompass sustainable development in healthcare, education, and living standards, as emphasized in the Human Development Index (HDI) (UNDP, 2021). It also requires integrating environmental sustainability and resource efficiency. Achieving an 'optimal' population involves assessing current conditions and considering future prospects to ensure improved living standards for future generations. This entails evaluating the impacts of population growth, technological advancements, and effective policy implementations.

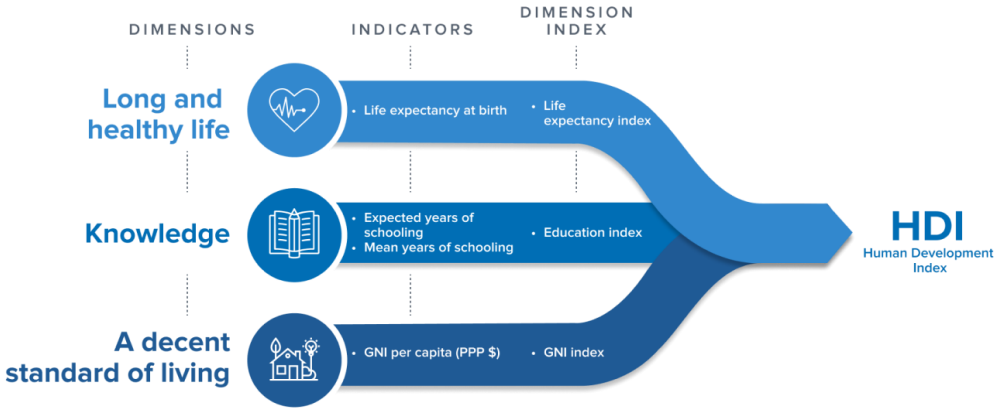


Figure 2.

In understanding the complexities of population growth, it's crucial to consider historical

perspectives and theories that have shaped our current viewpoints. One such foundational theory is Malthus, who posits that populations increase exponentially while food production grows at a linear rate, leading to inevitable shortages. He controversially suggested extreme measures, such as relocating the poor to swamps and forbidding treatments for diseases, reflecting an indifferent attitude towards the poor (Malthus, Thomas Robert, 1798). Nigeria exemplifies Malthus' theory, where from 1960 to 2015, rice production increased from 268,840 to 2,678,900 thousand metric tons, while demand rose from 300,569 to 3,399,000 thousand metric tons. This significant increase in demand supports Malthus' claim (Coats, A. W., & David Ricardo, 1973). During the 1960s and 1970s, Malthusian ideas resurged; in 1966, US President Lyndon Johnson made foreign aid contingent on population control measures (Zubrin, Robert, 2012), and in 1969, US President Richard Nixon established an independent Office of Population within USAID with a $50 million annual budget (Grebenik, E, 1974). By 1977, the office's chief, Dr. Reimert Ravenholt, openly expressed a desire to sterilize one-quarter of the world's women (Follett, Chelsea, 2021).

The International Food Policy Research Institute reported that due to the Green Revolution, which introduced high-yielding varieties, fertilizers, and irrigation practices, crop production in developing countries expanded significantly from 877 million metric tonnes in 1961 to 2.7 billion metric tonnes in 2020 (IFPRI, 2002). Additionally, my correlation analysis of the HDI and global population growth from 1990 to 2021 yielded a Kendall correlation coefficient of 0.99 (UNDP, 2021; United Nations, 2023), indicating a very strong positive correlation. This suggests that despite increasing population and potential diminishing returns, the benefits of technological advances outweigh these drawbacks. This finding also refutes David Ricardo's "Iron Law" theory, which posited that workers' real wages would tend to settle at subsistence levels over the long term. Instead, the sustained growth in HDI shows the opposite trend. Consequently, food production has greatly increased, supporting much larger populations than Malthus had anticipated.

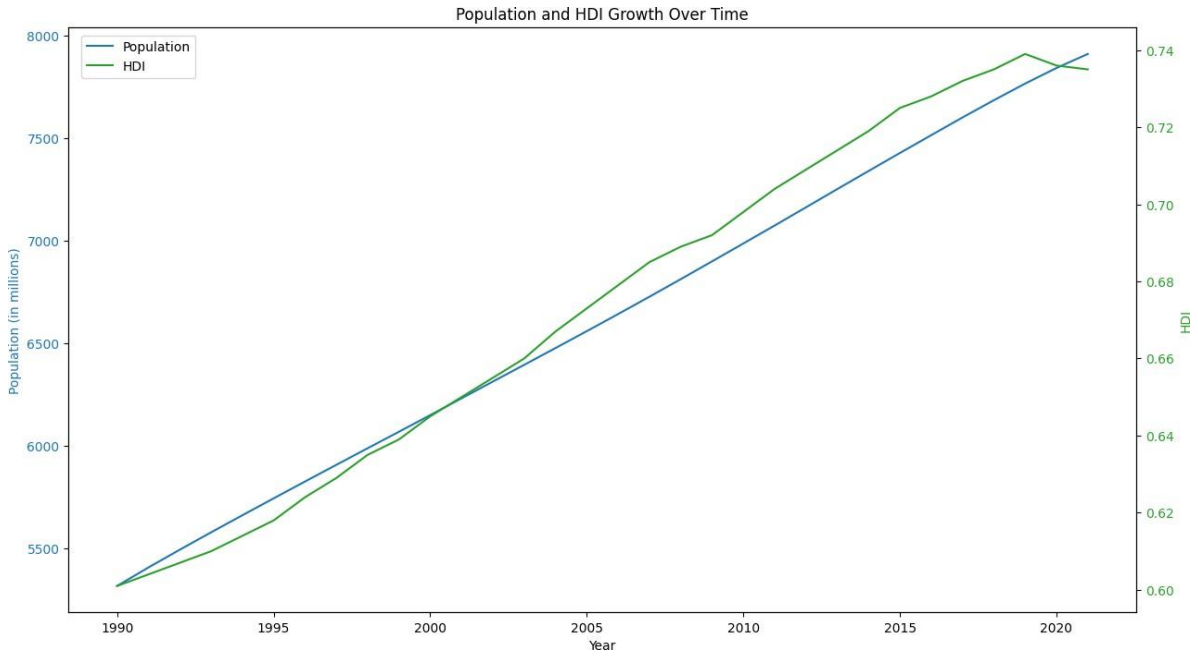


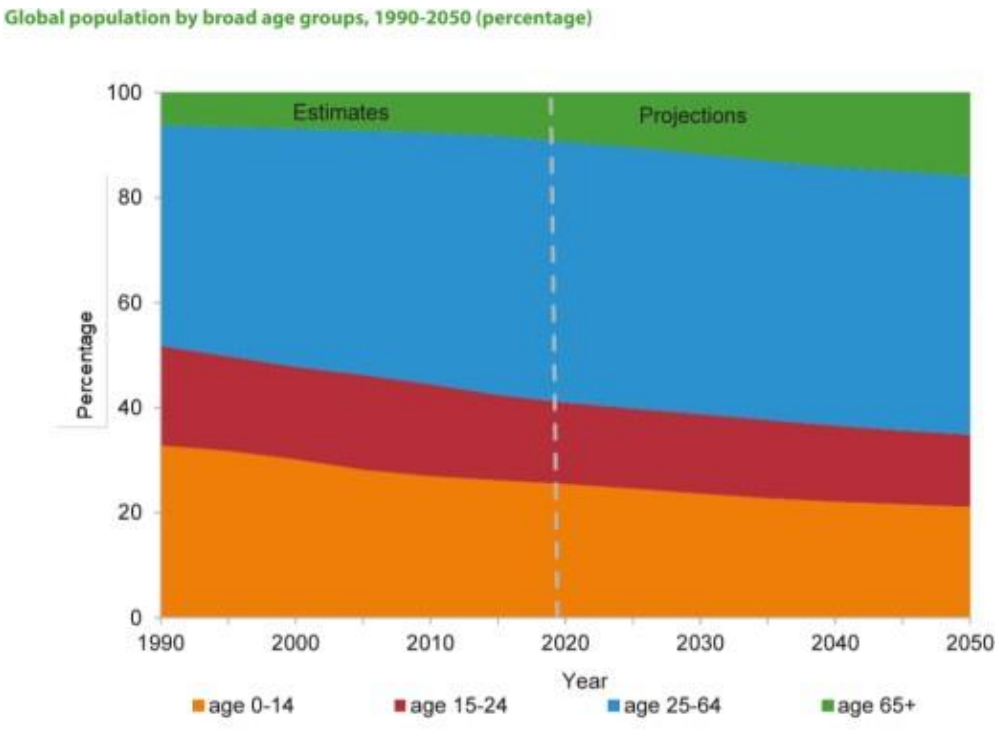
Figure 3.

Developments in agriculture and health sciences have significantly improved resource management, extended human life, and increased food production. These advancements demonstrate that fears of extreme scarcity due to overpopulation may be unwarranted. For instance, the work of Norman Borlaug and others during the Green Revolution introduced high-yielding crop varieties, modern irrigation, and synthetic fertilizers, resulting in substantial increases in agricultural productivity and economies of scale. Cereal yields in developing

countries rose from 420 million metric tons in 1960 to over 1.1 billion metric tons in 2000, an increase of more than two-and-a-half times (Fuglie, Keith et al., 2024). However, agricultural output growth faces diminishing marginal returns, as land supply and resources are finite. Additionally, advancements in biotechnology have extended human life spans. Vaccinations, antibiotics, and improved sanitation are examples of technological healthcare improvements that have lowered death rates and increased life expectancy worldwide. According to WHO's estimates, life expectancy at birth increased from 52.6 years in 1960 to 72.6 years in 2019 (Galvani-Townsend, Sarah, et al., 2022).

Furthermore, advanced technologies combined with AI are implemented into daily life and alter human lifestyle to become more convenient, with social media connecting nearly half of the global population. This connectivity increases overall happiness and life expectancy, thereby supporting an optimal global population. Additionally, a larger population enhances the job market, fostering innovation and cultural exchanges. The World Economic Forum found that workforce diversity is a key driver of economic success, with diverse businesses having a 35% higher chance of achieving financial returns above their industry medians (Tulshyan, Ruchika, 2015). Furthermore, advancements in AI and the achievement of Artificial General Intelligence (AGI) goals, along with the Internet of Things (IoT), improve the quality of life in comprehensive ways. 75% of today's knowledge workers use AI, which increases creativity by 84%, saves time by 90%, and improves job satisfaction by 83% (Microsoft and LinkedIn, 2024). Those examples demonstrate how technological progress can mitigate the challenges of population growth and enhance the Earth's carrying capacity.

To determine Earth's optimal population, consider the benefits of larger populations, especially with technological advancements. Compared to low-density rural areas, high population density can improve per capita carbon efficiency. Contrary to common belief, urban population growth, as argued by David Owen in 'Green Metropolis,' promotes sustainability by concentrating resources efficiently. Cities, occupying only 3% of global land, house over 50% of the population and are projected to accommodate 70% by 2050, without equivalent harm to natural habitats (David Owen, 2011). Moreover, growing populations can address challenges posed by aging demographics (Gorman, Linda, 2011). By 2050, the elderly population is expected to double, necessitating younger workforce. Increasing global population could stimulate economic vitality.



Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019*.

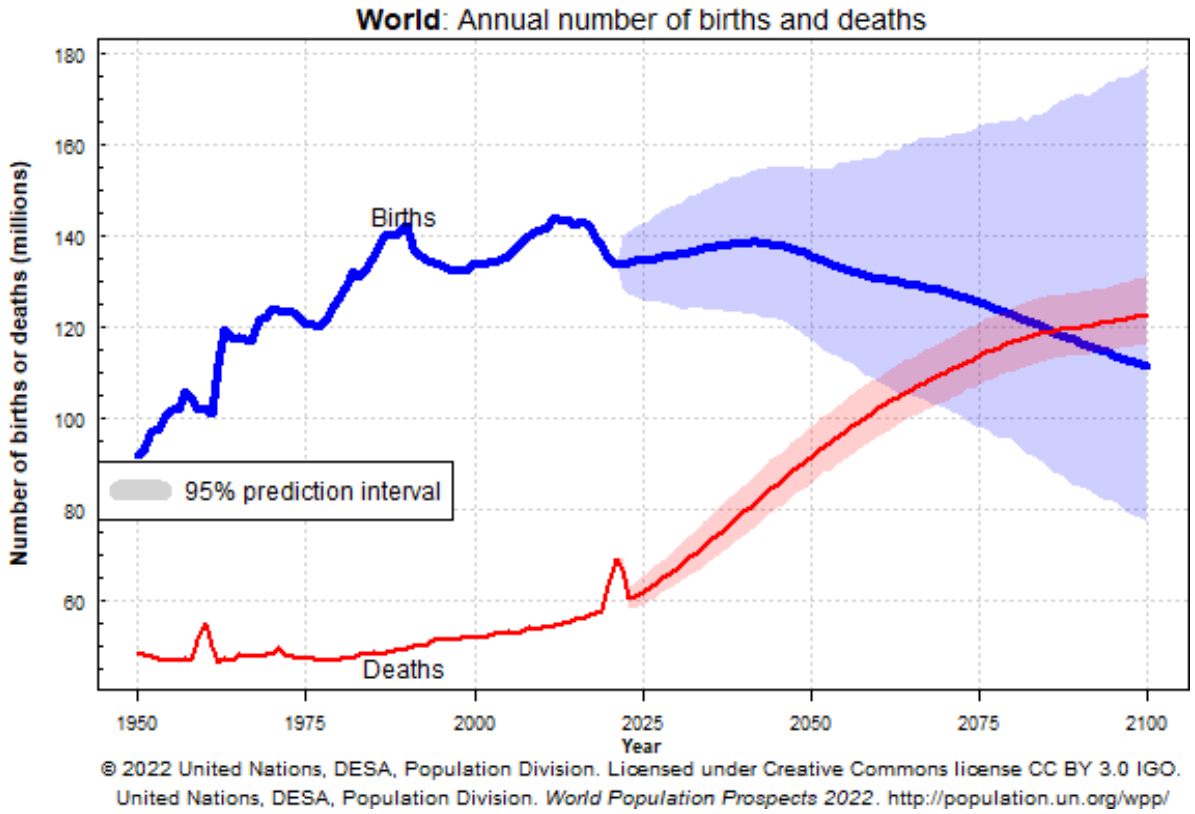


Figure 4.

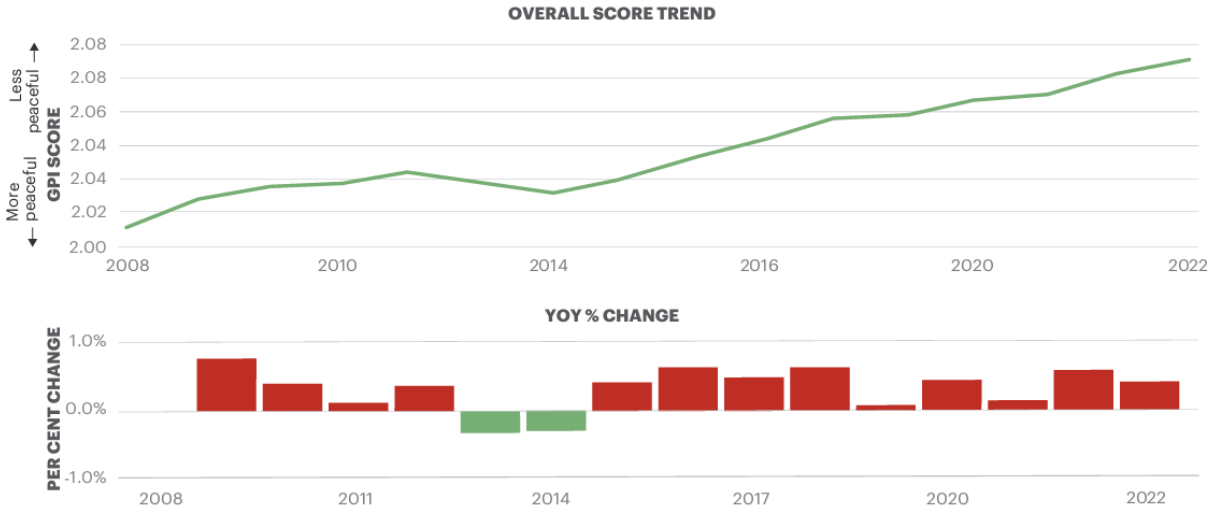
This kind of problems arose because the population increased by over four million in the past five years, leading to insufficient water resource supply (Ray, Sarbapriya & Ishita Aditya Ray, 2011). Similarly, research from MIT indicates that since 2019, conflicts over scarce resources and social unrest have been escalating both between nations and within regions like Mexico, exacerbated by economic difficulties and rapid population growth (Daron Acemoglu, Leopoldo Fergusson & Simon Johnson, 2019). The phenomenon of overpopulation also exacerbates environmental degradation, including pollution, greenhouse gas emissions, and climate change.

While population growth brings pressure on environmental pollution, resource efficiency, and global social issues, recent advancements in agriculture, energy, and health technologies offer sustainable solutions. The global shift to electric vehicles has significantly reduced carbon emissions, with electric vehicles emitting 3,932 pounds of CO2 equivalent annually compared to 11,435 pounds from gasoline vehicles (Christensen, Jen, 2024). Transitioning to clean energy and zero-emission vehicles could notably improve public health, aligning with the Net Zero Emissions by 2050 Scenario (NZE Scenario) (IEA, 2023). Technological innovations like lab-grown meat offer sustainable food sources without animal slaughter, though adoption remains limited (Wikipedia, 2019). Biotechnological advancements have revolutionized agriculture, significantly increasing yields and sustaining large populations. Advanced environmental technologies, like Direct Air Capture (DAC), capture carbon dioxide from the air, equivalent to the emissions of 250,000 cars annually (Budinis, Sara, 2023). Despite these advancements, global peacefulness, as measured by the Global Peace Index (GPI), has declined due to ongoing conflicts rather than population growth (Institute for Economics and Peace, n.d.).

FIGURE 2.1

GPI overall trend and year-on-year percentage change, 2008–2023

Peacefulness has declined year-on-year for thirteen of the last fifteen years.

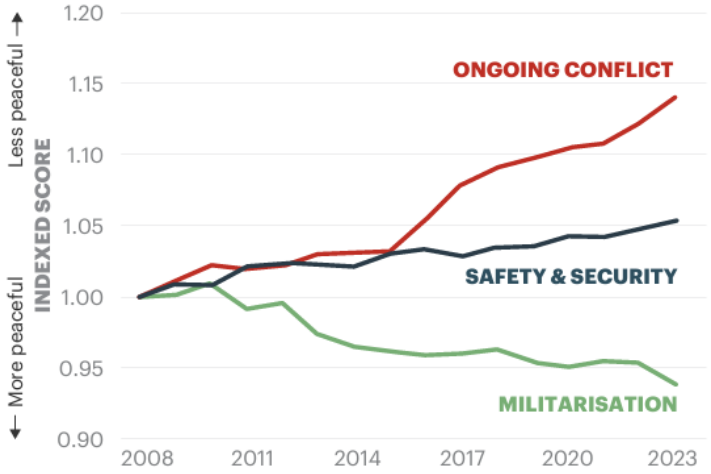


Source: IEP

FIGURE 2.3

Indexed trend in peacefulness by domain, 2008 to 2023 (2008=1)

Militarisation was the only domain to record an improvement since 2008.



Source: IEP

Figure 5.

Women's health advocates, then and now, argue that these policies infringe on women' s fundamental rights to decide if and when to have children (Population Reference Bureau, 2001). Nonetheless, population intervention policies are not solely about direct population control or coercion; they aim to promote balanced population development, mitigate aging population issues, and ensure a steady labor supply. Therefore, these policies are not entirely negative and can be beneficial for national development and public interest on a macro level. Modern policies focus on enhancing citizens' sexual education, providing subsidies to encourage labor force participation, and promoting immigration policies to increase the working-age population (World Health Organization, 2023).

Meanwhile, effective resource distribution within society is crucial. However, resource sufficiency is a long-term average concept. Unforeseen events can lead to scarcity and social disorder, as seen in the 2019 Hong Kong protests (Wikipedia, 2020). Thus, it is essential to consider not only resource adequacy during average years but also the social impact during below-average years, necessitating a buffer to calculate the optimal population.

Long-term visionary concepts, such as the colonization of Mars by visionaries similar to Elon Musk, could bring new frontiers for human settlement, thus relieving population pressure on Earth (SpaceX, 2024). Musk spoke of how the human population is not even remotely large and envisions a future where one trillion humans could yield a thousand Mozarts (Mollman, Steve, 2023). His argument for "the light of consciousness" stretching from beyond Earth speaks to new avenues for human development and sustainability.

Overall, historical changes in population have been significantly influenced by factors such as diseases and wars, both of which have been major drivers of sudden population declines. Although wars still occur, they are generally smaller in scale today, resulting in lower death tolls. Medical advancements have also led to lower fatality rates from diseases, although the COVID-19 pandemic has still caused significant loss of life (Centers for Disease Control and Prevention, 2020). These factors illustrate how both human actions, such as wars, and natural regulatory mechanisms, such as diseases, contribute to adjusting the population to more sustainable levels.

Elon Musk has proposed the idea of migrating to Mars in the event of Earth's population becoming too large (SpaceX, 2024). While this may appear implausible at present, it is worth considering that in the 20th century, few could have envisioned a scenario where smartphones would surpass the computing power of desktop computers even though a 1980s supercomputer (Team, Adobe Acrobat, 2022) — a reality that is now commonplace. Therefore, it is conceivable that humanity may continue to develop groundbreaking solutions to address overpopulation, even if it surpasses what is currently considered optimal.

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